

# JOURNAL

OF THE

## ASIATIC SOCIETY OF BENGAL.

---

### Part II.—NATURAL SCIENCE.

---

No. II.—1884.

---

III.—*Account of the South-West Monsoon Storms of the 26th June to 4th July and of 10th to 15th November 1883.*—By JOHN ELIOT, M. A., *Meteorological Reporter to the Government of Bengal.*

[Received June 4th ;—Read July 2nd, 1884.]

(With Plates II—X.)

#### CHAPTER I.

##### INTRODUCTION.

It is proposed in the following paper to give an account of the two most important and remarkable storms that occurred in the Bay of Bengal during the year 1883. The first storm was generated during the last week of June near the Head of the Bay and gave very stormy weather off the Bengal and Orissa coasts, and was the only occasion on which it was necessary to hoist the storm signals at the Saugor Island station near the entrance to the Hooghly. The second storm was formed in the Gulf of Martaban during the second week of November, almost at the end of the south-west monsoon, and pursued a very unusual course. It crossed into the Bay of Bengal through the channel between Cape Negrais and the Andaman Islands. It then slightly recurved and moved in a general northward direction, approaching the Arracan coast near Akyab, where it was broken up by the action of the Arracan Hills.

The following is a list of all the cyclonic storms in the Bay of Bengal during the south-west monsoon period of the year 1883. They were all of comparatively small extent and intensity, or ordinary south-west monsoon storms accompanied with winds of force 8 to 10 at and near the centre.

1. Storm of June 13th to 20th at the commencement of the south-west monsoon, which gave the first heavy burst of rainfall to Behar. It formed near the Balasore coast on the 13th, and advanced into Behar, where it broke up on the 20th.

2. Storm of June 26th to 4th July. This was generated slowly near the Sandheads on the 26th and 27th, was of considerable intensity, and remained nearly stationary until the 29th. It crossed the Balasore coast early on the morning of the 30th.

3. Storm of July 6th to 8th. This was formed at or near the Sandheads under similar conditions to the preceding, but was of small intensity. It crossed the Balasore coast on the afternoon of the 7th.

4. Storm of the 12th to 14th July. This began to form on the morning of the 12th off the South Orissa coast, across which (between False Point and Gopalpore) the centre advanced on the evening of the 13th, or early on the morning of the 14th, into the Central Provinces. It was of slight intensity.

5. Storm of the 16th to 18th August. This was formed in the north-west angle of the Bay, and crossed the North Orissa coast near Balasore. This storm was very small, of very slight intensity, and of no importance.

6. Storm of the 23rd to the 26th of August. This was generated further to the south than the preceding storm, and crossed the Ganjam coast between Gopalpore and Vizagapatam on the evening of the 25th. It was of slight intensity.

7. Storm of the 30th August to the 3rd of September. This depression crossed the coast near Balasore on the afternoon of the 2nd of September, and was of moderate intensity.

8. Storm of the 6th and 7th of September. This was formed immediately after the preceding, and followed along nearly the same track, crossing the Orissa coast to the south of Balasore on the morning of the 7th. It was of small intensity.

9. Storm of the 11th to the 15th of November. This was generated in the Martaban Gulf, and advanced in a north-westerly direction as far as Lat.  $16^{\circ}$  N. Long.  $93^{\circ}$  E. to the west of Diamond Island, when it recurved and moved northwards parallel to the coast, breaking up in the neighbourhood of Akyab during the afternoon of the 14th. This was the most severe and intense storm of the year in the Bay, but was



of very limited extent, and hence did not affect the weather in the north-west angle of the Bay.

10. Storm of the 2nd to the 4th of December, which gave heavy rain at a very unusual time of the year to Bengal.

Two of these were remarkable for the length of time that elapsed before they broke up after they had crossed the Bengal or Orissa coast, and also for the very heavy rainfall and floods which accompanied their existence on land. The first of these was the storm of June 13th to 20th which was formed in the immediate neighbourhood of the Balasore coast. It drifted through Chutia Nagpur and South Behar into North Behar and gave excessively heavy rain to a narrow area in Behar stretching from Gya to Motihari and Durbhunga. This storm was of little importance at sea.

The second storm of the series was similar in its general character. It was generated near the Head of the Bay, crossed the North Orissa coast, and advanced over the Orissa Hills into the Central Provinces. Instead of breaking up as do three out of four storms or cyclonic circulations which pass from the Bay into the Central Provinces, it acquired fresh energy and drew large supplies of vapour from the Bombay monsoon current. It advanced across the head of the Peninsula almost parallel to the valleys of the Nerbudda and Tapti. The heavy rain accompanying it caused excessive floods in these two rivers which inflicted much damage on the town of Surat, and others in the lower portion of the valleys of these two rivers. This cyclonic circulation apparently broke up in the Arabian Sea in the immediate neighbourhood of the Guzerat and Sind coasts.

The meteorology of India for the year 1883 was remarkable in several respects. One or two of the more important features had a direct bearing on the number and character of the cyclones.

During the cold weather months several storms of unusual character and magnitude passed over Northern India and the Himalayas from west to east. They gave excessive snowfall over the higher Himalayas and affected the weather certainly for many weeks and probably more or less permanently for the year. The accumulation of snow reduced temperature for some time and gave a strong northerly element to the air motion or wind circulation over Northern India. The south-west monsoon set in about the normal period on the Burmah and Bengal coasts, but it never obtained its usual hold in Northern India. The rains were irregular in occurrence and distribution, and much below the average over the whole of Northern India. The deficiency was quite as marked in North Bengal as in North Behar or Rohilkhand or in the Western districts of the Punjab. The monsoon was in ordinary language very weak, and

its weakness was more especially shown in Bengal by the early and complete termination of the rains in the last week of September.

The only theory which on the whole explains the phenomena of cyclonic generation and motion, *viz.*, the condensation theory, indicates that small cyclonic storms should be of frequent occurrence during the south-west monsoon, and that they should be most frequent when the monsoon is weak on land, or in other words, when the rainfall occurs to a smaller extent over the land and therefore usually to a greater extent over the sea area in the neighbourhood of the land. The rainfall in the Bay near the Burmah, Arracan, and Bengal coasts during the south-west monsoon of 1883 was, according to the various accounts received in the Meteorological Office, noticeably larger in amount than usual. The large number of cyclonic storms which formed during the period the south-west monsoon prevailed in Northern India in the year 1883 confirms this inference from theory.

After the south-west monsoon current finally retreated from Northern India in the last week of September, it recurved as usual over the Bay. The moisture brought up by it was, however, at once discharged on the Madras coast districts. The condensation theory indicates that there is a marked tendency during the transition period of October and November to the commencement and continuance of heavy rainfall over the centre of the Bay, and therefore to the generation of severe cyclonic storms at that period. If, however, the aqueous vapour or moisture is not discharged as rain over the Bay, but is carried westwards by the north-east monsoon winds and deposited on and near the Madras coast, the conditions for the formation of a cyclonic storm are not present in the Bay. In other words, if heavy general rain sets in and continues over the Madras coast at the change of this monsoon, the Bay will be free from severe and extensive storms. This rule was strikingly illustrated by the weather of the Bay and the Madras coast in October and November 1883.

The paper will deal with the subject under the following heads:—

1. History of the Storm of June 26th to July 4th.
2. Discussion of the more important features of the Storm of 26th June to 4th July.
3. History of the Storm of 10th to 15th November.
4. Discussion of the more important features and peculiarities of the Storm of 10th to 15th November.
5. General remarks on the generation of cyclones.

## CHAPTER II.

## HISTORY OF THE STORM OF JUNE 26TH TO JULY 4TH.

The south-west monsoon set in slightly earlier than usual on the Bengal coast in 1883, but with no great strength. Moderate rain fell over the whole of the Province of Bengal during the first fortnight. On the 12th there began to form, in the north-west angle of the Bay, between False-point and Saugor Island, and over the adjacent portion of south-west Bengal, a small barometric depression; and on the morning of the 13th, the winds in South-west Bengal and North Orissa indicated cyclonic convergence to it. The depression intensified on the 14th, and its centre was then to the north of and in the neighbourhood of Balasore. It advanced northwards through Chutia Nagpore and South Behar across the Ganges into the central districts of North Behar, and gave excessive rain over a narrow area stretching from Gya through Behar and Patna to Mozufferpore and Durbhunga. Amongst the remarkable rainfalls were the following :—

|                    | 15th | 16th | 17th  | 18th | 19th |
|--------------------|------|------|-------|------|------|
| Gya .....          | 1·01 | 9·04 | 0·21  | 0·01 | nil. |
| Behar .....        | 5·17 | 6·05 | 10·95 | 0·58 | 0·09 |
| Patna .....        | 1·23 | 6·35 | 5·13  | nil. | 0·05 |
| Mozufferpore ..... | 0·08 | 2·85 | 12·49 | 0·42 | nil. |
| Hajipur .....      | 0·86 | 4·51 | 9·39  | nil. | 0·14 |
| Durbhunga .....    | 0·53 | 1·02 | 5·02  | 8·52 | 0·24 |

The disturbance broke up in North Behar and finally disappeared on the 20th. During the next five days there was a partial break in the rains. The air was drier, sky less clouded, and rain showers local rather than general in character. The winds more especially diminished in strength, but continued to indicate the same general atmospheric motion over the Gangetic delta and valley as before. Southerly winds blew across the Bengal coast. In Northern Bengal and Behar the current was deflected up the Gangetic valley and hence gave winds blowing from directions varying generally between N. E. and S. E. In Chutia Nagpore and in Western Orissa the effects of the Bombay branch of the monsoon current were beginning to be shown by the prevalence of moist S. S. W. winds at Hazarabagh and of W. N. W.



winds at Cuttack. The Bombay branch of the monsoon current, it may be added, was late in being established on the Bombay coast, and was very feeble before the 20th of the month, when it rapidly increased in force, as measured by the strength of the winds.

The heavy rainfall attending the disturbance of the third week of the month had drained the southerly monsoon winds advancing into Bengal from the Bay of a very large portion of their moisture, and weakened them for some days. This is shown by the diminution in the amount of the rainfall and by the decreased velocity of the winds in Bengal.

The following table gives the average amount of the rainfall day by day between the 13th and the 26th in the various divisions in Bengal, and illustrates fully the general diminution in the rainfall of every part of the Province after the 20th :—

*Table of Average Rainfall recorded in Bengal, June 13th to 26th 1883.*

| PROVINCE.                                  | No. of Stations. | 13th. | 14th. | 15th. | 16th. | 17th. | 18th. | 19th. | 20th. | 21st. | 22nd. | 23rd. | 24th. | 25th. | 26th. |
|--|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orissa.....                                | 16               | 0·64  | 1·30  | 0·23  | 0·04  | 0·25  | 0·16  | 0·30  | 0·09  | Nil.  | 0·37  | 0·10  | 0·43  | 0·10  | 0·41  |
| S. W. Bengal                               | 46               | 0·31  | 0·78  | 0·42  | 0·26  | 0·27  | 0·26  | 1·02  | 0·31  | 0·66  | 0·26  | 0·45  | 0·10  | 0·18  | 0·07  |
| East Bengal                                | 26               | 0·18  | 0·51  | 1·62  | 1·11  | 0·86  | 1·00  | 1·48  | 0·46  | 0·82  | 0·33  | 0·17  | 0·18  | 0·16  | 0·11  |
| North Bengal                               | 27               | 0·09  | 0·21  | 0·91  | 1·79  | 1·71  | 0·47  | 1·23  | 2·25  | 0·97  | 0·33  | 0·72  | 1·09  | 0·98  | 0·96  |
| North Behar                                | 16               | 0·04  | 0·12  | 0·52  | 1·86  | 3·69  | 1·36  | 1·13  | 1·21  | 0·42  | 0·42  | 0·30  | 0·07  | 1·98  | 0·89  |
| South Behar                                | 17               | 0·29  | 0·08  | 1·40  | 3·37  | 1·99  | 0·92  | 0·35  | 0·11  | 0·04  | 0·09  | 0·38  | Nil.  | 0·38  | 0·77  |
| Chutia Nag-<br>pore & Son-<br>thal Perg. } | 16               | 0·39  | 0·50  | 2·04  | 0·48  | 0·21  | 0·56  | 0·63  | 0·97  | 0·15  | 0·37  | 0·13  | Nil.  | 0·19  | 0·35  |

The following table gives the daily amounts of wind for the same period at the chief Meteorological Stations in Orissa, Bengal, and Behar.



*Table of Daily Amount of Wind at eight Stations in Bengal.  
June 13th to 25th, 1883.*

|                 | 13th. | 14th. | 15th. | 16th. | 17th. | 18th. | 19th. | 20th. | 21st. | 22nd. | 23rd. | 24th. | 25th. | Average Daily Amount, June. |
|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----------------------------|
| False Point ... | 261   | 207   | 326   | 258   | 265   | 207   | 270   | 241   | 245   | 244   | ?     | 285   | 238   | 249                         |
| Calcutta .....  | 127   | 141   | 166   | 215   | 177   | 140   | 167   | 178   | 166   | 151   | 122   | 72    | 104   | 162                         |
| Dacca .....     | 102   | 174   | 164   | 174   | 177   | 160   | 193   | 229   | 217   | 211   | 181   | 142   | 155   | 186                         |
| Dinagepore ...  | 144   | 168   | 312   | 264   | 216   | 144   | 192   | 216   | 144   | 120   | 120   | 144   | 120   | ?                           |
| Purneah .....   | 76    | 100   | 170   | 111   | 126   | 114   | 255   | 158   | 24    | 26    | 21    | 47    | 29    | 98                          |
| Durbhunga ...   | 137   | 185   | 279   | 148   | 278   | 153   | 58    | 74    | 127   | 57    | 59    | 116   | 134   | 137                         |
| Patna .....     | 117   | 148   | 206   | 251   | 114   | 58    | 60    | 121   | 138   | 55    | 111   | 107   | 127   | ?                           |
| Hazaribagh ...  | 99    | 134   | 191   | 286   | 329   | 182   | 206   | 153   | 239   | 136   | 211   | 182   | 178   | 214                         |

The rainfall table shews a very marked diminution in the amount of rain after the 20th. An examination of the complete rainfall returns of the Province of Bengal indicates that it occurred as isolated and local showers, which were occasionally heavy and gave large amounts at single stations. No general rain, however, fell over any considerable portion of the Province between the 20th and 25th. Similarly, an examination of the second table giving wind amounts indicates that, although strong winds generally prevailed between the 13th and 20th, winds were unusually light after the 20th and below their normal strength. This feature of weakness of its air motion was most markedly shown by the stations most distant from the sea, as, for example, Purneah.

The meteorological observations taken in Bengal thus show that what may be termed a strong monsoon prevailed at the Head of the Bay and in Bengal from the 1st to the 20th of the month, and that for some days afterwards, or between the 20th and the 25th, it was much feebler. Also, as will be seen from the following observations and from the history of the storm, the south-west monsoon winds increased in force to the west of the Andamans on the 23rd, advanced northwards as a strong atmospheric current along the coasts of Burmah and Arracan, and fed the cyclonic vortex which formed on the 26th and 27th with large supplies of aqueous vapour.

*Table of Daily Amount of Wind at seven Stations to the east of the Bay.  
July 22nd to 28th, 1883.*

|                     | Average<br>June. | 22nd. | 23rd. | 24th. | 25th. | 26th. | 27th. | 28th. |
|---------------------|------------------|-------|-------|-------|-------|-------|-------|-------|
| Nancowry .....      | 263·5            | 115·0 | 98·8  | 97·3  | 124·2 | 252·7 | 354·5 | 289·8 |
| Port Blair .....    | 257·6            | 128·7 | 212·9 | 386·0 | 283·8 | 305·4 | 315·6 | 323·0 |
| Diamond Island..... | 203·0            | 122·9 | 118·5 | 118·7 | 240·7 | 310·4 | 346·6 | 336·5 |
| Akyab .....         | 93·6             | 42·7  | 48·9  | 55·4  | 83·6  | 100·9 | 153·8 | 234·4 |
| Chittagong .....    | 168·3            | 162·6 | 113·5 | 72·9  | 71·9  | 50·1  | 117·7 | 212·2 |
| Saugor Island ..... | 332·4            | 362·7 | 312·4 | 284·7 | 235·2 | 144·5 | 137·1 | 357·4 |
| Dacca .....         | 183·7            | 211·1 | 181·1 | 142·8 | 155·0 | 68·8  | 66·8  | 181·1 |

The preceding table shows that on the 22nd and 23rd the winds were barely half their normal strength over the east of the Bay. A rapid increase took place on the 24th at Port Blair, which extended to Diamond Island on the 25th and to Akyab and Chittagong on the 26th and 27th.

These figures suggest what is also indicated by the whole of the Bengal observations, *viz.*, that the weather in the Bay between the 20th and 23rd of June was that which usually accompanies the commencement of a partial break in the rains in Bengal or Northern India. Winds were light and unsteady over the whole of the north and centre of the Bay. The logs of vessels show that occasional rain-squalls local in character occurred, more especially in the south of the Bay. The observations at Port Blair, Nancowry, Diamond Island, and Akyab and of the ships traversing the Bay at the time, however, prove conclusively that south-westerly winds prevailed over the whole of the Bay; and the Bengal observations establish that they were continued in Bengal and Behar as southerly and easterly winds. They also indicate that on the 24th a change occurred in the character of the winds to the west of the Andamans which lasted for some days. A very considerable increase occurred in the south-west winds of that part of the Bay which rapidly and steadily extended northwards.

Hence prior to the morning of the 25th the gradients were normal in direction, although smaller in amount than the average for the season, over the Bay; the winds blew from the usual quarter and gave rise to the normal atmospheric current up the Gangetic valley. The only indication afforded at this time by the land observations of the subsequent stormy weather was the occurrence of a partial break in the rains, which, as has been ascertained by previous experience, establishes conditions which are favourable to the development of a cyclonic disturbance if an adequate motive power or disturbance act on the atmosphere.

The account of the storm of the last week of June hence begins with the 25th of June, the day before which there were any indications of the actual formation of an atmospheric whirl at the Head of the Bay.

*25th of June.*—The atmosphere was in a slightly disturbed state over nearly the whole of India. The barometer was rising in the North-Western Provinces, Bengal, and the south of the Peninsula, but elsewhere it was falling. A large depression accompanying the establishment of the south-west monsoon in Western India was advancing along the west coast of India and causing the barometer to fall quickly. Winds had backed to south-east on the 24th at Bombay. On the 25th, winds were southerly along the Bombay coast and easterly in Cutch. There were strong indications that gales of considerable force were blowing on and near the Bombay coast. The weather was cloudy everywhere, except in the Punjab; and rain in small or moderate amounts was falling in every part of India, except the Punjab, Behar, Sind, and parts of the Madras Presidency. The rainfall was very small in amount and local in its distribution over the North-Western Provinces, Bengal, Rajputana, and the North Bombay districts.

The following table gives the more important observations taken at the Coast Stations on the Bay of Bengal on the 25th June, 1883:—

| STATIONS.                     | 10 A. M.<br>Barometer reduc-<br>ed to sea level. | Change since<br>10 A. M. 24th. | Wind direction. |          | Wind velocity of<br>previous 24 hours<br>miles per hour. | Percentage of<br>wind amount to<br>average. | Cloud<br>10 A. M. | Rainfall<br>of<br>previos<br>24 hours. |
|-------------------------------|--|--------------------------------|-----------------|----------|--|---|-------------------|--|
|                               |  |                                | 10 h.           | 16 h.    |  |   |                   |  |
| Nancowry .....                | 29·941   | + ·047                         | S. S. W.        | S. S. W. | 5  | 45  | 8                 | 0·14                                   |
| Port Blair .....              | 29·911   | + ·069                         | S. W.           | S. W.    | 14   | 127   | 10                | 1·05                                   |
| Diamond Island                | 29·847   | + ·024                         | S. W.           | W. S. W. | 8  | 100   | 9                 | 0·24                                   |
| Akyab .....                   | 29·792   | + ·019                         | E. S. E.        | S.       | 4  | 100   | 9                 | 1·35                                   |
| Chittagong ...                | 29·802   | + ·027                         | S. E.           | S. W.    | 3  | 43  | 10                | 0·15                                   |
| Dacca .....                   | 29·752   | + ·024                         | S.              | S. E.    | 7  | 88  | 10                | ...                                    |
| Jessore .....                 | 29·745   | + ·040                         | calm.           | S. S. W. | 7  | 140   | 8                 | ...                                    |
| Calcutta (Ali-<br>pore) ..... | 29·719   | + ·025                         | S.              | S. S. W. | 5  | 83  | 9                 | 0·05                                   |
| Saugor Island                 | 29·775   | + ·053                         | S.              | S. S. E. | 31   | 221   | 3                 | 0·21                                   |
| Balasore .....                | 29·715   | + ·010                         | S. W.           | ?        | 5  | ?   | 3                 | ...                                    |

| STATIONS.       | 10 A. M.<br>Barometer reduc-<br>ed to sea level. | Change since<br>10 A. M. 24th. | Wind direction. |          | Wind velocity of<br>previous 24 hours<br>miles per hour. | Percentage of<br>wind amount to<br>average. | Cloud<br>10 A. M. | Rainfall<br>of<br>previous<br>24 hours. |
|-----------------|--|--------------------------------|-----------------|----------|--|---|-------------------|---|
|                 |  |                                | 10 h.           | 16 h.    |  |   |                   |   |
| Cuttack.....    | 29.695   | + .015                         | W. S. W.        | S.       | 3  | 75  | 9                 | 1.01                                    |
| False Point ... | 29.722   | + .005                         | Calm.           | E.       | 11   | 110   | 8                 | 0.03                                    |
| Vizagapatam     | 29.672   | — .027                         | W.              | W. by S. | 6  | 150   | 8                 | ...                                     |

Pressure had increased rather rapidly over the province of Bengal during the previous 24 hours. The general result of the changes of pressure since the dispersion of the disturbance of the third week of the month had been to give a high barometer, which culminated on the morning of the 25th in excessively high readings. The barometric readings at 10 A. M. of that day in Bengal were above the average by amounts which varied from .19" at Saugor Island to .09" at Durbhunga. Winds were, however, generally normal in direction, blowing from south in South-West Bengal, south-east in East Bengal, east in North and Central Behar, and south-west in Chutia Nagpore.

The unusual weakness of the wind is shown by the following comparison table:—

|                     | Wind amount<br>of 24 hours<br>preceding<br>10 A. M. | Average<br>daily wind<br>amount June. | Percentage<br>of actual to<br>average wind<br>amount. |
|---------------------|---|---------------------------------------|---|
| Saugor Island ..... | 256.9   | 332.4                                 | 77.3  |
| Calcutta.....       | 104.0   | 152.3                                 | 68.3  |
| Berhampore .....    | 132.6   | 132.3                                 | 100.2   |
| Dacca .....         | 162.1   | 183.7                                 | 88.3  |
| Jessore .....       | 118.3   | 118.3                                 | 100.0   |
| Chittagong .....    | 71.5  | 168.3                                 | 42.5  |
| Burdwan .....       | 110.7   | 124.2                                 | 89.1  |
| Cuttack .....       | 40.0  | 96.3                                  | 41.5  |
| False Point .....   | 263.3   | 247.2                                 | 106.5   |

The average rainfall in each of the seven meteorological divisions of Bengal for the 24 hours preceding 6 P. M. of the 25th June is given in page 58.

The following table gives the meteorological information for the 25th extracted from the logs of vessels:—



| Vessel.     | Hour.   | Latitude.          | Longitude. | Probable reduced barometer, | Wind.    |        | REMARKS.   |
|-------------|---------|--------------------|------------|-----------------------------|----------|--------|--|
|             |         |                    |            |                             | Dir.     | Force. |  |
| Bancoora    | 4 A. M. |                    |            | 29·899                      | S. S. W. | 3      | 8 A. M. Light breeze and hazy.   |
|             | 8 A. M. |                    |            | 30·988                      | N. E.    | 2      | 11 A. M. Heavy rain squall.  |
|             | Noon    | N. 5° 58' by D. R. | E. 80° 58' | ·963                        | W. S. W. | 3      | Noon. Moderate breeze and fine.  |
|             | 4 P. M. |                    |            | 29·889                      | S. W.    | 3      |  |
|             | 8 P. M. |                    |            | ·901                        | S. W.    | 3      |  |
|             | Midnt.  |                    |            | ·889                        | S. W.    | 3      | Midnight. Moderate breeze and clear.                                       |
| India ..... | 4 A. M. |                    |            |                             | S.       | 4      | Moderate breeze with passing squalls.                                      |
|             | 8 A. M. |                    |            | 29·750                      | N. W.    | 3      | Breeze moderating and fine.  |
|             | Noon    | N. 15° 10'         | E. 83° 14' | ·730                        | W.       | 3      | Moderate breeze and fine.  |
|             | 4 P. M. |                    |            |                             | W.       |        | Moderate fresh wind; cloudy with showers.                                  |
|             | 8 P. M. |                    |            | ·730                        | W.       | 4      | Fresh breeze and overcast.   |
|             | Midnt.  |                    |            | ·730                        | W.       | 3      | Threatening to N.W. with lightning.  |
| Himalaya    | 4 A. M. |                    |            | 29·712                      | S. S. W. |        |  |
|             | 8 A. M. |                    |            | ·747                        | W. S. W. |        |  |
|             | Noon    | N. 15° 13'         | E. 82° 29' | ·737                        | S. W.    | 3      | Moderate breeze and overcast.  |
|             | 4 P. M. |                    |            | ·731                        | W. S. W. |        |  |
|             | 8 P. M. |                    |            | ·734                        | S. W.    |        |  |
|             | Midnt.  |                    |            | ·757                        | S. W.    |        |  |
| Roma .....  | 4 A. M. |                    |            |                             | S. W.    | 5      | Fresh breeze and moderate sea.   |
|             | 8 A. M. |                    |            |                             | ...      | ...    |  |
|             | Noon    | N. 17° 15'         | E. 85° 17' |                             | ...      | 0 to 3 | Moderate variable wind with very heavy rain squalls and dark overcast sky. |
|             | 4 P. M. |                    |            |                             | ...      | 4      | Rain squalls.  |
|             | 8 P. M. |                    |            |                             | ...      | ...    | Lightning, similar weather and high S. S. W. sea.                          |
|             | Midnt.  |                    |            |                             | ...      | ...    | Overcast sky.  |

| Vessel.             | Hour.   | Latitude. | Longitude. | Probable reduced barometer. | Wind.    |        | REMARKS.  |
|---------------------|---------|-----------|------------|-----------------------------|----------|--------|---|
|                     |         |           |            |                             | Dir.     | Force. |   |
| Saint Magnus        | 4 A. M. |           |            | 29.690                      | W. S. W. | 4      |   |
|                     | 8 A. M. | N.        | E.         | .700                        | S. W.    | 4      |   |
|                     | Noon    | 18° 31'   | 86° 29'    | .710                        | W.       | 1      |   |
|                     | 4 P. M. |           |            | .680                        | S.       | 1      | Calms and rain.   |
|                     | 8 P. M. |           |            | .710                        | S. W.    | 5      | Cloudy, lightning to S. W. & S. E.  |
| Star of Albion      | 4 A. M. |           |            | 29.730                      |          |        |   |
|                     | 8 A. M. | N.        | E.         | .740                        |          |        | Easterly current.   |
|                     | Noon    | 18° 46'   | 86° 40'    | .740                        | W.       | 4 to 5 | Squally.  |
|                     | 4 P. M. |           |            | .710                        |          |        | Cloudy weather.   |
|                     | 8 P. M. |           |            | .720                        |          |        |   |
| Scottish Chief-tain | 8 A. M. |           |            | 29.680                      |          | 0      | Very light airs and dark cloudy weather.  |
|                     | Noon    | N.        | E.         | .690                        | S. by W. | 1      |   |
|                     | 4 P. M. | 18° 58'   | 86° 34'    | .690                        | S. W.    | 2      | Strong westerly current.  |
|                     | 8 P. M. |           |            | .660                        | N. N. W. | 3      |   |
| British Princess    | 4 A. M. |           |            |                             | S. by W. | 5      | Cloudy sky and S. W. swell.   |
|                     | 8 A. M. |           |            |                             | S. W.    | 4      | Variable winds.   |
|                     | Noon    | N.        | E.         |                             |          |        |   |
|                     | 4 P. M. | 19° 9'    | 85° 15'    | 29.700                      | E.       | 2      | Fine clear weather.   |
|                     | 8 P. M. |           |            |                             | E. S. E. | 4      | Squally with rain.  |
|                     | Midnt.  |           |            |                             | S.       | 3      | Cloudy sky.   |
| Prince Amadeo       |         |           |            |                             | W. S. W. | 4      | S. W. swell moderating.   |
|                     |         |           |            |                             | S. S. E. |        | Midnight.   |
|                     | 4 A. M. |           |            |                             | S. W.    | 4      | A. M. Weather clearing, wind moderate. 4 A. M. Gentle wind, fine weather. Noon. Close sultry weather. Sea smooth. |
|                     | Noon    | N.        | E.         | 29.700                      | S.       | 4      |   |
| Commilla .....      | 4 P. M. |           |            |                             | E. S. E. | 3      | 4 P. M. Weather fine. Sea very smooth.  |
|                     | 8 A. M. |           |            |                             | Variable | 2      | Showery.  |
|                     | Noon    | N.        | E.         |                             | S. E.    | 3      | Clear weather and smooth sea.   |
|                     | 4 P. M. | 20° 13'   | 92° 28'    | 29.611                      | S. S. E. | 3      | Fine weather.   |
|                     | 8 P. M. |           |            | .683                        | S. E.    | 4      | Fine weather and lightning to eastward.   |
|                     | Midnt.  |           |            | .671                        | E. S. E. | 4      | Clear weather and smooth sea.   |

The logs of the vessels received in the Meteorological office give an imperfect view of the weather in the Bay, as they were chiefly those of steamers passing up to Calcutta along the west coast of the Bay.

The Bancoora rounding Ceylon had light to moderate south-west breezes (force 1 to 3) during the day. The India and Himalaya were a few miles apart off the coast to the south-east of Coconada. The former was in Lat.  $15^{\circ} 10'$  N. and Long.  $83^{\circ} 14'$  E. at noon and the latter in Lat.  $15^{\circ} 13'$  N. and Long.  $82^{\circ} 29'$  E. Both had moderate breezes and overcast skies. The winds were of force 3 and from directions between W. and S. W. The Roma, in Lat.  $17^{\circ} 15'$  N. and Long.  $85^{\circ} 17'$  E. at noon, had moderate variable winds with calms and very heavy rain squalls. The Star of Albion, Scottish Chieftain, and Saint Magnus were all near each other off the Gopalpore coast. The winds were very light and unsteady, but were generally from directions between west and south-west. The Scottish Chieftain had calms at 8 A. M., and the Saint Magnus calms and rain at 4 P. M. The British Princess and Prince Amadeo were a little further to the north. The former, in Lat.  $19^{\circ} 9'$  N. and Long.  $85^{\circ} 15'$  E. at noon, had variable winds during the day varying in force between 2 and 5. The latter, in Lat.  $19^{\circ} 23'$  N. and Long.  $86^{\circ} 56'$  E., had gentle south-west winds, sultry weather, and a smooth sea. There were hence no indications on this day of the existence of an atmospheric whirl in the Bay.

*26th June.*—During the previous 24 hours the barometer had risen rapidly at the Bombay stations, and the depression off that coast was much less marked than on the 25th at Bombay and the adjacent coast stations. South-westerly gales were blowing, but the rainfall brought up by them was as yet moderate in amount. In parts of Southern and Central India the barometer had also risen, but over the whole of Northern India a considerable fall had taken place. Along the foot of the hills, from Assam to the Punjab, the wind was generally easterly or north-easterly, and in the Central Provinces and Central India it was westerly. The weather was dull and sky overcast over the whole country except the Punjab, and rain was falling except in North-Western and Central India, but the amounts registered were in the great majority of cases small. The rainfall returns, as compared with the average rainfall between June 1st and 26th, shew that there was a deficiency of from 1 to 3 inches over the plains of the Punjab, the western half of the North-Western Provinces, Central India, and Rajputana, and of 7 inches in Bombay.

The following are the more important observations taken at 10 A. M. of the 26th at the selected stations near the Head of the Bay :—

| STATIONS.          | 10 A. M. Barometer reduced to sea level. | Change since 10 A. M. 25th. | Wind.    |          | Average wind velocity of previous 24 hours. | Wind percentage | Cloud 10 A. M. | Rainfall of previous 24 hours. |
|--------------------|--|-----------------------------|----------|----------|---|-----------------|----------------|--------------------------------|
|                    |  |                             | 10 h.    | 16 h.    |   |                 |                |                                |
| Nancowry .....     | 29·915                                   | —·026                       | S. W.    | S. W.    | 11  | 100             | 7              | ...                            |
| Port Blair .....   | 29·886                                   | —·025                       | S. W.    | S. W.    | 11  | 100             | 10             | 0·32                           |
| Diamond Island...  | 29·801                                   | —·046                       | S.       | S. W.    | 10  | 125             | 8              | 1·26                           |
| Akyab.....         | 29·711                                   | —·081                       | S. E.    | S. S. E. | 4   | 100             | 9              | 1·98                           |
| Chittagong.....    | 29·660                                   | —·142                       | S. E.    | E.       | 2   | 29              | 5              | 0·01                           |
| Dacca .....        | 29·682                                   | —·070                       | S.       | S. E.    | 6   | 75              | 9              | 1·67                           |
| Jessore .....      | 29·673                                   | —·072                       | S.       | S.       | 6   | 120             | 10             | 0·04                           |
| Calcutta (Alipore) | 29·646                                   | —·073                       | E. S. E. | E. by S. | 3   | 50              | 8              | 0·71                           |
| Saugor Island ...  | 29·647                                   | —·128                       | S. E.    | E. S. E. | 7   | 50              | 2              | 0·08                           |
| Balasore .....     | 29·636                                   | —·079                       | N. N. E. | ?        | 2   | ?               | 6              | ...                            |
| Cuttack .....      | 29·626                                   | —·069                       | S. S. W. | Calm.    | 1   | 25              | 9              | 0·12                           |
| False Point. ....  | 29·621                                   | —·101                       | N. E.    | E.       | 8   | 80              | 4              | ...                            |
| Vizagapatam .....  | 29·668                                   | —·004                       | W.       | W.       | 5   | 125             | 6              | 0·10                           |

Pressure, it will be seen from the above, had given way, and the fall was greatest at Saugor Island and Chittagong. This was due, as shewn by the wind directions, to the formation of an area of cyclonic disturbance and barometric depression near the Head of the Bay. The winds at Saugor Island had shifted to south-east, at False Point to north-east, and at Gopalgore to north-west. From the information extracted from the logs, it will be seen that light north-east winds were established over a considerable portion of the north-west of the Bay. Hence, the cyclonic circulation was just beginning to affect the direction of air motion at Saugor Island and was causing it to back. It was, however, not yet participating directly in the cyclonic indraught. The sky was more or less clouded in all parts of the province of Bengal, the air very damp (especially in Behar, after the floods of the previous week), and winds unusually light and somewhat unsteady.

The following table gives the average rainfall in the seven divisions of the province of Bengal for the 24 hours preceding 6 P. M. :—



Table of Average Rainfall in Bengal on the 26th June 1883.

| Name of Province.            | Average Rain. |
|------------------------------|---------------|
| Orissa .....                 | 0·41          |
| South West Bengal.....       | 0·07          |
| East Bengal .....            | 0·11          |
| North Bengal .....           | 0·96          |
| North Behar.....             | 0·89          |
| South Behar.....             | 0·77          |
| Sonthal Pergannahs and ..... | } 0·35        |
| Chutia Nagpore .....         |               |

The following extracts from the logs of vessels give information respecting the Bay on the 26th :—

| Vessel.        | Hour.   | Latitude.  | Longitude. | Probable reduced barometer. | Wind.            |        | REMARKS.   |
|----------------|---------|------------|------------|-----------------------------|------------------|--------|--|
|                |         |            |            |                             | Dir.             | Force. |  |
| Bancoora       | 4 A. M. |            |            | 29·876                      | SW. by S.        | 2      | 4 A. M. Light breeze and fine.   |
|                | 8 A. M. |            |            | ·883                        | SW. by S.        | 2      | 8 A. M. Light following wind and clear.                                |
|                | Noon    | N. 8° 35'  | E. 82° 35' | ·863                        | S.W. by S.       | 2      |  |
|                | 4 P. M. |            |            | ·780                        | W S. W.          | 2      |  |
|                | 8 P. M. |            |            | ·856                        | S. S. W.         | 2      |  |
|                | Midnt.  |            |            | ·816                        | S. S. W.         | 3      | Evening. Moderate breeze and fine.                                     |
| Pemba ...      | Noon    | N. 16° 46' | E. 96° 12' |                             |                  |        | 10 A. M. At Rangoon.   |
|                | 4 P. M. |            |            |                             | S. W.            | 5      | Unmoored and proceeded towards Calcutta.                               |
|                | Midnt.  |            |            | 29·750                      | ...              | 5      | Midnight. Fresh to moderate breezes and frequent rain squalls.         |
| Himalaya       | 4 A. M. |            |            | 29·657                      | W.               |        |  |
|                | 8 A. M. |            |            | ·635                        | W.               |        |  |
|                | Noon    | N. 17° 32' | E. 84° 38' | ·615                        | W.               |        | Moderate breeze and overcast.  |
|                | 4 P. M. |            |            | ·506                        | S. W.            |        |  |
|                | 8 P. M. |            |            | ·586                        | W. S. W.         |        | Moderate breeze and fine.  |
|                | Midnt.  |            |            | ·539                        | W. S. W.         |        |  |
| Star of Albion | 8 A. M. | N. 19° 21' | E. 86° 20' | 29·700                      |                  |        | Principally light unsteady winds, finer at night than in the day time. |
|                | Noon    |            |            | ·630                        | W. to SW & N. W. | 4 to 2 |  |
|                | 4 P. M. |            |            | ·620                        |                  |        |  |

| Vessel.             | Hour.   | Latitude.  | Longitude. | Probable reduced barometer. | Wind.          |         | REMARKS.   |
|---------------------|---------|------------|------------|-----------------------------|----------------|---------|--|
|                     |         |            |            |                             | Dir.           | Force.  |  |
| British Princess    | 4 A. M. |            |            |                             | W. S. W.       | 4       | Dark cloudy sky.   |
|                     | 8 A. M. |            |            |                             | W. N. W.       | 3       | Light green sky.   |
|                     | Noon    | N. 19° 30' | E. 87° 3'  | 29° 600                     | N. N. E.       | 4       | Weather fine and clear with S. W. swell.   |
|                     | 4 P. M. |            |            |                             | E. N. E.       | 3       |  |
|                     | 8 P. M. |            |            |                             | E.             | 0 to 3  | High southerly swell and cloudy, the stars showing through with great brilliancy.  |
|                     | Midnt.  |            |            |                             | W. N. W.       | 5       |  |
| India .....         | 4 A. M. |            |            |                             | W.             | 4       | Strong winds & squally with clouds.  |
|                     | 8 A. M. |            |            | 29° 610                     | N. by E.       | 3       | Moderating breezes and cloudy weather.   |
|                     | Noon    | N. 19° 36' | E. 86° 33' | ° 630                       | ...            | 3       | Moderate breeze and cloudy.  |
|                     | 4 P. M. |            |            | ° 630                       | N. E.          |         | Moderate breeze, fine.   |
|                     | 8 P. M. |            |            | ° 590                       | Calm.          |         | Calm and clear.  |
|                     | Midnt.  |            |            | ° 580                       | N. E.          | 3       | Moderate breeze with passing clouds.   |
| Saint Magnus        | 4 A. M. |            |            | 29° 610                     | W.             | 4       | Cloudy weather.  |
|                     | 8 A. M. | N.         | E.         | ° 610                       | N.             | 2       |  |
|                     | Noon    | 19° 47'    | 87° 18'    | ° 600                       | N. E.          | 1       | Faint airs and calms.  |
|                     | 4 P. M. |            |            | ° 530                       | E.             | 1       | Faint airs, calms, heavy southerly sea.  |
|                     | 8 P. M. |            |            | ° 590                       | N. W.          | 1       | Cloudy with lightning.   |
|                     | Midnt.  |            |            | ° 550                       | N. W.          | 5       | Cloudy.  |
| Prince Amadeo       | 4 A. M. | N.         | E.         |                             | N.             | Light.  | 4 A. M. Heavy cloudy and unsettled looking weather. Much lightning and southerly swell. Noon, similar looking weather, light variable airs; unsettled looking all round, high southerly swell. |
|                     | Noon    | 19° 52'    | 87° 9'     | 29° 600                     | N. to NE.      | Light.  |  |
|                     | 8 P. M. |            |            |                             | W. to W. N. W. | Gentle. | 8 P. M. same weather, much lightning.  |
| Scottish Chieftain. | 4 A. M. |            |            | 29° 640                     | S. S. W.       | 0       | A strong current setting about W. Winds very unsteady in force and direction.  |
|                     | 8 A. M. | N.         | E.         |                             | S. E.          | 1       |  |
|                     | Noon    | 20° 04'    | 86° 58'    | ° 600                       | E.             | 2       |  |
|                     | 4 P. M. |            |            |                             | E. S. E.       | 3       |  |
|                     | 8 P. M. |            |            |                             | E. N. E.       | 4       |  |
|                     | Midnt.  |            |            | ° 580                       | S. E.          | 4       |  |

| Vessel.      | Hour.          | Latitude.  | Longitude. | Probable reduced barometer. | Wind.    |        | REMARKS.   |
|--------------|----------------|------------|------------|-----------------------------|----------|--------|--|
|              |                |            |            |                             | Dir.     | Force. |  |
| Roma .....   | 4 A. M.        |            |            |                             | W.       |        | 4 A. M. swell from S. S. W. overcast sky and rain.                                   |
|              | 8 A. M.        |            |            |                             | North    | 3      | 8 A. M. Gentle breeze, sky clearing at intervals.                                    |
|              | Noon           | N. 20° 19' | E. 86° 50' |                             | N.       | 3      | Noon, similar weather with southerly swell, light breeze, sky clearing at intervals. |
|              | 4 P. M. midnt. |            |            |                             | N. E.    | 1      |  |
|              |                |            |            |                             | N. E.    | 1      | 10 P. M. light showers.  |
| Commilla ... | 4 A. M.        |            |            | 29·635                      | E. N. E. | 3      | Light cloudy weather.  |
|              | 8 A. M.        |            |            | ·642                        | E. N. E. | 3      |  |
|              | Noon           | N. 22° 21' | E. 91° 50' | ·607                        | E. N. E. | 4      |  |
|              | 4 P. M.        |            |            |                             | East     | 4      | Threatening appearance to S. E. Squally with very heavy rain.                        |
|              | 8 P. M.        |            |            | ·543                        | S. S. E. | 4      | Continuous heavy rain.   |

The Nancowry and Port Blair observations prove that strong steady south-westerly winds continued to blow in that part of the Bay. These winds were also extending to Diamond Island. The average wind velocity during the past 24 hours at that station was 10 miles, and for the previous day had been 8 miles per hour. The sea was also reported to be rising. Hence it is certain that the vigorous current indicated by the strong winds at Port Blair on the 25th was steadily advancing up the east of the Bay, and that its front was off the West Burmese coast on the morning of the 26th. The Pemba, which left Rangoon at 10 A. M., had south-westerly winds of force 5 with frequent rain squalls, as she advanced westwards in the Martaban Gulf to the south of the Burmese coast.

It is almost certain that this strong current was giving heavy rain over a portion of the north-east of the Bay in the neighbourhood of the Burmese and Arracan coasts. The direct evidence of this does not appear in the extracts from the logs of the vessels given above, but it will appear in those for the 27th. It is, however, indicated by the large rainfall at Diamond Island and other stations in South Burmah and in Arracan.

For the present we shall accept it as almost certain that in the front

of this advancing strong moisture current, where the resistance to its advance was greatest, and where therefore ascensional motion was necessarily occurring to a large extent, rainfall of a more or less concentrated character was going on. The current was being deflected to the west by the coast and the Burmese and Arracan hills, and was moving more rapidly in its eastern than in its western portion. Hence probably also arose a strong tendency to an eddying motion in front and towards the west. The various actions going on were thus such as might set up vorticose motion. That such a result was taking place was indicated by the wind observations of all the vessels near the Head of the Bay. The Himalaya, in Lat.  $17^{\circ} 32' N.$  and Long.  $84^{\circ} 75' E.$ , had moderate westerly winds. The India, British Princess, Star of Albion, Scottish Chieftain, Saint Magnus, Roma, and Prince Amadeo, which were all between Lat.  $19^{\circ} 20' N.$  and  $20^{\circ} 19' N.$  and between Long.  $86^{\circ} 20' E.$  and  $87^{\circ} 18' E.$ , experienced light unsteady north-easterly winds. The weather was fine and sky clear during the greater part of the day, but became more clouded during the evening. There was a heavy swell from the south during the day. This was evidently due to the strong winds and high sea prevalent in the centre and south-east of the Bay. The only log which gives any indication of the subsequent weather is that of the Prince Amadeo, in which the Captain notes that, although light variable airs were blowing, the appearance of the sky was unsettled in all directions. Probably the light green sky to the east noted by the Captain of the British Princess was another sign of the large amount of moisture brought up by the southerly winds in the East of the Bay.

The various observations of the 26th hence indicate that cyclonic motion on a considerable scale commenced on the afternoon of the 25th over a portion of the Head of the Bay. The atmospheric whirl was fed and maintained by a very strong south-westerly air current moving northwards up the Bay near the Burmah and Arracan coast. It was apparently formed in the front of this air-current, and was causing winds to draw round over the north-west of the Bay. The indraught from that quarter was, however, feeble and unimportant, except as an indicator of bad weather to the south-east.

*27th June.*—The decrease of pressure which commenced on the 26th had now extended over the whole country. The change was still greatest in the north. On the northern frontier of the Punjab, in Eastern and Lower Bengal, and at Akyab the decrease exceeded one-tenth of an inch. It was smallest in parts of Bombay and Madras, where it only amounted to two or three-hundredths of an inch. A considerable depression lay over the Punjab. This, however, is a frequent feature of the hot weather months of June and July in that province. A smaller depression was, however,



forming at the Head of the Bay to the south of Saugor Island. Pressure ranged from 29·9 inches in Ceylon to 29·28 inches at Peshawar.

The wind was from directions between south-west and west over the Peninsula. In the neighbourhood of the two depressions, cyclonic circulations were established. Up the Gangetic valley the wind had a general easterly direction. The weather was cloudy and gloomy in all parts of the country except in the upper districts of the Punjab. Rain in small amounts had fallen during the preceding 24 hours, except in the Punjab, Sind, and West Madras. The rainfall was heavier on the Bombay coast than it had been hitherto, and strong monsoon winds were blowing there.

The following table gives the observations at the selected stations on and over the coast of the Bay on the 27th :—

| STATIONS.           | 10 A. M.<br>Barometer<br>reduced to<br>sea level. | Change<br>since<br>yesterday. | Wind.    |          | Average<br>wind velocity | Wind<br>percentage | 10 A. M.<br>Cloud. | Rainfall of<br>previous<br>24 hours. |
|---------------------|---|-------------------------------|----------|----------|--------------------------|--------------------|--------------------|--------------------------------------|
|                     |   |                               | 10 h.    | 16 h.    |                          |                    |                    |                                      |
| Nancowry .....      | 29·912  | —·003                         | S. W.    | S. S. W. | 15                       | 136                | 8                  | ...                                  |
| Port Blair .....    | 29·853  | —·033                         | S. W.    | S. W.    | 13                       | 118                | 10                 | ...                                  |
| Diamond Island ...  | 29·763  | —·038                         | S. S. W. | S. S. W. | 14                       | 175                | 8                  | 1·79                                 |
| Akyab .....         | 29·606  | —·105                         | S. S. E. | S. S. E. | 6                        | 150                | 10                 | 0·57                                 |
| Chittagong .....    | 29·578  | —·082                         | E. N. E. | S. E.    | 3                        | 43                 | 4                  | 1·02                                 |
| Dacca.....          | 29·566  | —·116                         | E.       | E.       | 3                        | 38                 | 8                  | 1·16                                 |
| Jessore .....       | 29·604  | —·069                         | E. N. E. | E.       | 6                        | 120                | 10                 | 0·04                                 |
| Calcutta (Alipore)  | 29·529  | —·117                         | E. S. E. | E.       | 5                        | 83                 | 9                  | 0·20                                 |
| Saugor Island ..... | 29·532  | —·115                         | N. N. E. | N. E.    | 35                       | 250                | 7                  | 0·09                                 |
| Balasore .....      | 29·537  | —·099                         | N.       | ?        | 1                        | ?                  | 8                  | 0·40                                 |
| Cuttack.....        | 29·565  | —·061                         | N. W.    | N. N. W. | 3                        | 75                 | 10                 | 1·01                                 |
| False Point .....   | 29·544  | —·077                         | W.       | W. S. W. | 7                        | 70                 | 10                 | 0·26                                 |
| Vizagapatam .....   | 29·634  | —·034                         | W.       | W. S. W. | 7                        | 175                | 10                 | 1·70                                 |

The preceding observations show that pressure had decreased rapidly over the north of the Bay and the adjacent coasts during the preceding 24 hours. The fall was greatest in South-West Bengal and more especially at Saugor Island. The distribution of pressure, taken in connection with the wind directions at the Bengal and Orissa stations, in-

dicates that there was now a well-defined atmospheric whirl at the Head of the Bay, the centre of which was at a little distance to the S. S. E. of Saugor Island. Pressure was below the normal for the day over the province of Bengal by amounts varying from '1" at Chittagong to zero at Patna. Winds were very light over the whole province. Northerly winds had fully set in over South-West Bengal and Orissa, whilst winds more or less easterly prevailed over East and North Bengal, Behar, and Chutia Nagpore.

This weakness of the winds is shown by the following observations :—

|                  | Amount of<br>wind<br>during<br>24 hours<br>preceding<br>10 A. M. | Average<br>wind<br>amount.<br>June. | Percentage<br>of actual<br>to average. |
|------------------|--|-------------------------------------|--|
| Calcutta.....    | 139.0  | 152.3                               | 91.3                                   |
| Berhampore ..... | 94.7   | 132.3                               | 71.6                                   |
| Dacca.....       | 63.1   | 183.7                               | 34.3                                   |
| Purneah.....     | 24.0   | 94.4                                | 25.3                                   |
| Hazaribagh ..... | 130.5  | 214.9                               | 60.9                                   |

The slight indraught to the cyclonic disturbance from the north and east had already diminished the humidity of the air and the amount of cloud in North Bengal and Behar. The sky was overcast in Orissa and South-West Bengal and the southern districts of East Bengal. The rainfall in the province was small in amount and localized in its distribution, except in Orissa and the southern districts of South-West Bengal, where moderate rain had already begun to fall in connection with the cyclonic disturbance.

The weather in Orissa at this time is described as unsettled. Winds were light and variable and gave occasional showers of rain.

The following table gives the average rainfall in each of the divisions of Bengal for the 24 hours preceding 6 P. M. :—

*Rainfall Table of the 27th June 1883.*

| Province.                                  | Number of<br>stations<br>in each<br>division. | Average<br>Rainfall of<br>preceding<br>24 hours. | Heaviest fall<br>reported in<br>24 hours. |
|--|---|--|---|
| Orissa.....                                | 16  | 0.17   | 2.25                                      |
| South-West Bengal .....                    | 46  | 0.28   | 2.20                                      |
| East Bengal .....                          | 26  | 0.49   | 2.50                                      |
| North Bengal .....                         | 27  | 0.09   | 0.57                                      |
| North Behar .....                          | 16  | 0.13   | 0.67                                      |
| South Behar .....                          | 17  | 0.16   | 0.69                                      |
| Sonthal Pergunnahs and<br>Chutia Nagpore } | 16  | 0.24   | 0.84                                      |

The meteorological extracts from logs of the vessels relating to the 27th of June are tabulated below for reference.

| Vessel.        | Hour.   | Latitude.  | Longitude.    | Probable reduced barometer. | Wind.     |        | REMARKS.  |
|----------------|---------|------------|---------------|-----------------------------|-----------|--------|---|
|                |         |            |               |                             | Dir.      | Force. |   |
| Bancoora       | 4 A. M. |            |               | 29·751                      | S. W.     | 4      | Brisk breeze, fine.   |
|                | 8 A. M. |            |               | ·796                        | SW. by S. | 4      | Fresh following wind and fine.  |
|                | Noon    | N. 11° 42' | E. 84° 8' 30" | ·796                        | S. W.     | 4      | Current S. 23 W. 17 miles.  |
|                | 4 P. M. |            |               | ·706                        | S. W.     | 4      | Fresh following wind and fine.  |
|                | 8 P. M. |            |               | ·816                        | S. W.     | 5      | Strong breeze and overcast.   |
|                | Midnt.  |            |               |                             |           |        | Less wind with occasional rain.   |
| Pemba          | 4 A. M. |            |               | 29·690                      | S. W.     | 5      | A. M. Fresh breeze with moderate sea and occasional rain squalls.                                       |
|                | 8 A. M. |            |               | ·720                        | S. S. W.  | 6      | 6-15 A. M. Passed Alguada.  |
|                | Noon    | N. 16° 13' | E. 93° 30'    | ·720                        | S. S. W.  | 7      | Noon. Strong breeze with rising sea.  |
|                | 4 P. M. | (by D.R.)  | (by D.R.)     | ·690                        | S. S. W.  | 9      | Afternoon. Wind rapidly increased to a strong gale with furious squalls blowing away sails and awnings. |
|                | 8 P. M. |            |               | ·660                        | S. S. W.  | 9      |   |
|                | Midnt.  |            |               | ·640                        | S. S. W.  | 9      |   |
| Himalaya       | 4 A. M. |            |               | 29·514                      | N. W.     |        |   |
|                | 8 A. M. |            |               | ·549                        | N. N. W.  |        |   |
|                | Noon    | N. 19° 58' | E. 86° 32'    | ·484                        | N. E.     |        | Moderate breeze and fine.   |
|                | 4 P. M. |            |               | ·404                        | N.        |        |   |
|                | 8 P. M. |            |               | ·447                        | N.        |        |   |
|                | Midnt.  |            |               | ·359                        | N. N. W.  |        | Overcast with rain.   |
| Star of Albion | 8 A. M. |            |               |                             |           |        |   |
|                | Noon    | N. 20° 10' | E. 87° 28'    | 29·500                      | W.        | 4      | Squally, with rain distant thunder to Northward and heavy looking clouds.                               |
|                | 4 P. M. |            |               |                             | N. W.     | 4      | Clearer to S. E.  |

| Vessel.              | Hour.   | Latitude.     | Longitude.    | Probable reduced barometer. | Wind.    |       | REMARKS.  |
|----------------------|---------|---------------|---------------|-----------------------------|----------|-------|---|
|                      |         |               |               |                             | Dir.     | Force |   |
| British Princess     | 4 A. M. |               |               |                             | N. W.    | 5     | Cloudy sky, southerly swell.  |
|                      | 8 A. M. |               |               |                             | N. W.    | 5     | Heavy squall with rain, overcast, passing showers.  |
|                      | Noon    | N.<br>20° 38' | E.<br>88° 2'  | 29·500                      | N. W.    | 5     | Heavy rain at intervals, sky overcast and weather finer.                                    |
|                      | 4 P. M. |               |               |                             | N. W.    | 5     | Sky looking very unsettled patches of green colour.   |
|                      | 8 P. M. |               |               |                             | N. W.    | 6     | 11 P. M. Heavy bank of clouds in the N. W. with vivid lightning, distant thunder, and rain. |
|                      | Midnt.  |               |               |                             | N. W.    | 7     |   |
| Scottish Chief-tain. | 4 A. M. |               |               |                             | W. S. W. | 1     | The whole of this day, the weather has been very unsteady. — Strong westerly current.       |
|                      | 8 A. M. |               |               | 29·520                      | S. W.    | 2     |   |
|                      | Noon    | N.<br>20° 40' | E.<br>87° 50' | ·480                        | S. W.    | 3     |   |
|                      | 4 P. M. |               |               | ·460                        | N. W.    | 4     |   |
|                      | Midnt.  |               |               | ·450                        | N. W.    | 5     |   |
| Saint Magnus         | 4 A. M. |               |               | 29·500                      | W. N. W. |       | Cloudy, rainy, squally weather.   |
|                      | 8 A. M. |               |               | ·540                        | North    | 5     | Thick rainy weather.  |
|                      | Noon    | N.<br>20° 44' | E.<br>87° 54' | ·450                        | N. W.    | 5     | Cloudy and passing showers.   |
|                      | 4 P. M. | (by D. R.)    |               | ·400                        | N. W.    | 2     | Squally, rainy weather.   |
|                      | 8 P. M. |               |               | ·460                        | N. N. W. | 4     |   |



| Vessel.        | Hou <sup>r</sup> . | Latitude.                  | Longitude.                 | Probable reduced barometer. | Wind.    |        | REMARKS.   |
|----------------|--------------------|----------------------------|----------------------------|-----------------------------|----------|--------|--|
|                |                    |                            |                            |                             | Dir.     | Force. |  |
| Prince Amadeo  | 4 A. M.            |                            |                            |                             | N. W.    |        | Midnight—Moderate W. to W. N. W. winds unsettled looking weather. 4 A. M. Squally with heavy rain. Noon, squally winds from N. W. to N. E., much rain high S. to S. S. E. swell. 8 P. M. Moderate N. W. winds, weather same. |
|                | Noon               | N.<br>20° 46'<br>(by D. R) | E.<br>87° 35'<br>(by D. R) | 29·500                      |          | Vble   |  |
| India .....    | 4 A. M.            |                            |                            | 29·530                      | E.       | 3      | Moderate and overcast.   |
|                | 8 A. M.            |                            |                            | ·520                        | E.       | 2      |  |
|                | Noon               | N.<br>20° 39'              | E.<br>88° 5'               | ·520                        |          |        |  |
| Roma .....     | 4 A. M.            |                            |                            |                             | ...      | 3      | A. M. Light showers 3 A. M. Anchored at Sangor. 9 A. M. proceeded up the river, weather showery.   |
|                | 8 A. M.            |                            |                            |                             | ...      | 5      |  |
|                | Noon               |                            |                            |                             | N. E.    | ...    |  |
| Commilla ..... | 8 A. M.            |                            |                            | 29·523                      | S. S. E. | 3      | Cloudy and threatening to S. E.  |
|                | Noon               | N.<br>22° 21'              | E.<br>91° 50'              | ·499                        | S. S. E. | 4      | Heavy unsettled appearance to S. E.  |
|                | 4 P. M.            |                            |                            | ·396                        | South    | 4      | Squally unsettled appearance to S. E.  |
|                | 8 P. M.            |                            |                            | ·411                        | S. S. E. | 4      | Hard squalls and threatening appearance with light rain at times. High sea getting up from S.  |
|                | Midnt.             |                            |                            | ·379                        | S. S. W. | 5      | Wild squally weather. High sea from S. S. W. Rain at times.  |

The strong south-west monsoon winds which the meteorology of the 26th shewed to be advancing northwards up the eastern part of the Bay, were on the morning of the 27th not far from the Head of the Bay and were certainly in the parallel of Akyab. The wind velocity was very considerable at Port Blair and Nancowry. Strong winds were also blowing at Diamond Island, where the sea was now rough. The wind velocity at Akyab had increased from a rate of 4 miles per hour to 6 miles per hour, the average force of the wind in June at that station being 4 miles. The remarks in the log of the *Pemba* are very valuable. She passed round Cape Negrais into the Bay to the west of Burma in the morning. The wind increased very rapidly to a strong gale and blew in furious squalls. The wind was steady at S. S. W. and of average force 9. On the other hand, the winds at the stations in South Bengal and Orissa, and also those observed at the Light Vessels and the vessels near the Head of the Bay, were very feeble. The only conclusion warranted by the evidence is that these strong winds on the Burmah and Arracan coast were feeders to an ascending current to the northward; and that the ascensional movement was hence near the Head of the Bay, and was partly maintained by the rainfall accompanying the ascensional motion, and by the various resistances to the motion of the strong current advancing northwards. The south-west winds, it has already been remarked, were much stronger than those from any other direction. It is, so far as can be judged, probable, if not certain, that the whirl was not at this time a fully developed cyclonic disturbance with a well-defined centre. The centre of the barometric depression at the Head of the Bay can only be roughly approximated from the observations. Its most probable position at noon was in Lat.  $20\frac{1}{2}^{\circ}$  N. and Long.  $89\frac{3}{4}^{\circ}$  E. and almost identical with its position at 10 A. M. Assuming this position of the centre of depression, the relative positions of the Light Vessels at 10 A. M. and of the ships at Noon are given in the following table :—

|                               | Time.    | Position.           |                    | Barometer. | Wind.      |           | Direction of Centre. | Distance from probable position of Centre. | Weather. |
|-------------------------------|----------|---------------------|--------------------|------------|------------|-----------|----------------------|--|----------|
|                               |          | Latitude.           | Longitude.         |            | Direction. | Strength. |                      |  |          |
| Saugor Island Light House...  | 10 A. M. | N. $21^{\circ} 39'$ | E. $88^{\circ} 5'$ | 29.505     | N. N. E.   |           |                      | Miles. 120                                 | Cloudy.  |
| Upper Gasper Light Vessel ... |          | N. $21^{\circ} 31'$ | E. $88^{\circ} 3'$ | 29.484     | N. E.      | 4         | ESE                  | 120  | Squally. |

|                                 | Time. | Position.       |                  | Barometer. | Wind.                 |           | Direction of centre. | Distance from probable position of centre. | Weather, &c.                      |
|---------------------------------|-------|-----------------|------------------|------------|-----------------------|-----------|----------------------|--|-----------------------------------|
|                                 |       | Latitude.<br>N. | Longitude.<br>E. |            | Direction.            | Strength. |                      |  |                                   |
| Intermediate Light Vessel...    | Noon. | 21° 15'         | 88° 11'          | 29·472     | E.N.E.                | 3         | ESE                  | miles 115                                  | Showery.                          |
| Eastern Channel Light Vessel... | ...   | 21° 1'          | 88° 12'          | 29·478     | N.N.E.                | 5         | ESE                  | 105  | High Sea.                         |
| Balasore .....                  | ...   | 21° 30'         | 86° 50'          | 29·479     | N.                    |           | ESE                  | 205  | Gloomy.                           |
| False Point .....               | ...   | 20° 20'         | 86° 47'          | 29·522     | S. W.                 |           | E.                   | 195  | Gloomy.                           |
| Saint Magnus....                | ...   | 20° 44'         | 87° 54'          | 29·450     | N. W.                 | 5         | E.                   | 120  | Squally.                          |
| Scottish Chieftain              | ...   | 20° 40'         | 87° 50'          | 29·480     | S. W.                 | 3         | E.                   | 120  | Unsettled.                        |
| Star of Albion ...              | ...   | 20° 10'         | 87° 28'          | 29·570     | W.toS.<br>W.<br>&N.W. | 4         | ENE                  | 150  | Squally.                          |
| British Princess                | ...   | 20° 38'         | 88° 2'           | 29·500     | N. W.                 | 5         | E.                   | 110  | Unsettled.                        |
| Prince Amadeo ...               | ...   | 20° 46'         | 87° 35'          | 29·500     | NW.to<br>N. E.        |           | E.                   | 145  | Squally.                          |
| Himalaya .....                  | ...   | 19° 58'         | 86° 32'          | 29·484     | N. E.                 |           | ENE                  | 210  | Fine.                             |
| Pemba .....                     | ...   | 16° 13'         | 93° 30'          | 29·720     | S.S.W.                | 7         | N.<br>W.             | 380  | Strong in-<br>creasing<br>breeze. |

The position of the centre at 4 P. M. was probably almost identical with its position at noon. The following observations taken at 4 P. M. indicate that it was at that hour in Lat. 20° 35' N. and Long. 89° 35' E.

|                                 | Position.       |                  | Barometer. | Wind.      |           | Direction of centre. | Distance from probable position of centre. | Weather, &c. |
|---------------------------------|-----------------|------------------|------------|------------|-----------|----------------------|--|--------------|
|                                 | Latitude.<br>N. | Longitude.<br>E. |            | Direction. | Strength. |                      |  |              |
| Saugor Island Light House...    | 21° 39'         | 88° 5'           | 29·407     | N. E.      | Light.    | S. E.                | miles 125                                  | Cloudy.      |
| Upper Gasper Light Vessel...    | 21° 31'         | 88° 3'           | 29·375     | Calm.      | 0         | E. S. E.             | 120  |              |
| Intermediate Light Vessel...    | 21° 15'         | 88° 11'          | 29·355     | N. N. E.   | 1         | E. S. E.             | 102  | Sea rough.   |
| Eastern Channel Light Vessel... | 21° 1'          | 88° 12'          | 29·377     | N. E.      | 2½        | S. E.                | 95   | Stormy.      |
| False Point .....               | 20° 20'         | 86° 47'          | 29·406     | WS.W.      | moderate  | E.                   | 175  | Gloomy.      |

The Bancoora was in Lat.  $11^{\circ} 42' N.$  and Long.  $84^{\circ} 8' E.$  at noon. She had strong steady south-west winds of force 4 during the day, with overcast skies and occasional rain.

The Pemba was in the north of the Gulf of Martaban early in the morning, when she experienced fresh breezes with moderate sea and occasional rain-squalls. She doubled Cape Negrais and passed into the Bay of Bengal about midday. The wind began to increase rapidly, and during the afternoon and evening it blew a gale with furious squalls, which carried away her sails and awnings. The wind blew steadily from the S. S. W. during the afternoon with average force 9.

The remaining vessels were all in the north-west angle of the Bay. They were the India, Himalaya, Star of Albion, Scottish Chieftain, Saint Magnus, British Princess, and Prince Amadeo, and were at noon between Lat.  $19^{\circ} 58'$  and Lat.  $20^{\circ} 46' N.$  and between Long.  $86^{\circ} 32'$  and  $88^{\circ} 5' E.$  Their observations enable the storm-centre to be approximately identified, as in the majority of these vessels the usual midday observations were taken; so that the positions of the vessels are known in nearly all cases with approximate exactness at noon of this day.

The Saint Magnus and British Princess were very near each other. The former was in Lat.  $20^{\circ} 40' N.$  and Long.  $87^{\circ} 50' E.$  and the latter in Lat.  $20^{\circ} 38' N.$  and Long.  $88^{\circ} E.$  Both experienced strong currents during the day. These two vessels were probably nearest the centre, but in the westerly quadrant. They had squally weather with thick rain and north-westerly winds of average force 5.

The Scottish Chieftain, which was about 10 miles to the west of the previous vessels, had very variable winds during the day, which increased in force from 1 to 5. They shifted from W. S. W. to S. W., and then hauled to N. W. She experienced a strong westerly current.

The Prince Amadeo, about 15 miles further to the west, in Lat.  $20^{\circ} 46' N.$  and Long.  $87^{\circ} 35' E.$ , had unsettled weather with light variable winds and heavy rain. She experienced a strong southerly current.

The Himalaya, which was considerably further to the west and near the Orissa coast, had moderate north-easterly breezes and fine weather.

*28th June.*—The barometer rose quickly in the Punjab, during the previous 24 hours, and was standing at its normal height at 10 A. M. Pressure continued to give way over the rest of India. The fall was not large in amount, except in and near the depression at the Head of the Bay. The barometer had fallen at Saugor Island from  $29.53''$  at 10 A. M. on the 27th to  $29.37''$  at the same hour of the 28th.

The wind had backed to south-west and south over the Central Provinces, Central India, and Rajputana. This was evidently due to the continuance of strong westerly winds on the Bombay coast and their



extension eastwards over the centre and north of the Peninsula. Light easterly winds were blowing, as on the 27th, up the Gangetic plain, indicating that the circulation was as yet unaffected in direction by the atmospheric whirl in the north of the Bay. To the north of the centre of depression, or in South Bengal, the circulation was increasing, but was still very weak. The weather was generally cloudy, and rain had fallen in moderate amounts over the same areas as on the 27th.

The observations at the selected stations in Bengal are given below :

| Stations.          | Barometer at 10 A. M. reduced to sea level. | Change since yesterday. | Wind.    |          | Average wind velocity of previous 24 hours. | Percentage wind. | 10 A. M. Cloud. | Rainfall of previous 24 hours. |
|--------------------|---|-------------------------|----------|----------|---|------------------|-----------------|--------------------------------|
|                    |   |                         | 10 h.    | 16 h.    |   |                  |                 |                                |
| Nancowry .....     | 29·913                                      | + ·001                  | S. W.    | S. W.    | 13  | 118              | 6               | nil.                           |
| Port Blair .....   | 29·856                                      | + ·003                  | S. W.    | S. W.    | 12  | 109              | 6               | 0·13                           |
| Diamond Island     | 29·807                                      | + ·044                  | S.       | S. S. W. | 29  | 363              | 9               | 0·25                           |
| Akyab .....        | 29·639                                      | + ·033                  | S.       | S. S. W. | 12  | 300              | 10              | 6·84                           |
| Chittagong .....   | 29·571                                      | — ·007                  | S. E.    | E. S. E. | 9   | 129              | 9               | 3·81                           |
| Dacca .....        | 29·526                                      | — ·040                  | E.       | E.       | 6   | 75               | 10              | 0·85                           |
| Jessore .....      | 29·445                                      | — ·159                  | E.       | E. S. E. | 6   | 120              | 10              | 0·10                           |
| Calcutta (Alipore) | 29·392                                      | — ·137                  | E.       | E. by N. | 9   | 150              | 10              | 0·22                           |
| Saugor Island ...  | 29·374                                      | — ·158                  | N. N. E. | N. N. E. | 8   | 57               | 10              | 0·91                           |
| Balasore .....     | 29·423                                      | — ·114                  | N.       | ?        | 2   | ?                | 10              | 0·32                           |
| Cuttack .....      | 29·507                                      | — ·058                  | calm.    | N. W.    | 4   | 100              | 10              | 0·62                           |
| False Point .....  | 29·452                                      | — ·092                  | W. S. W. | W. S. W. | 10  | 100              | 10              | 4·84                           |
| Vizagapatam ...    | 29·614                                      | — ·020                  | W.       | W.       | 7   | 175              | 10              | 0·20                           |

Pressure had given way over the whole of the Province of Bengal, and was below the normal of the day by amounts varying between '05" at Patna and '25" at Saugor Island. The air-motion over the whole of Bengal was now largely dependent on the cyclonic vortex. In East and South-West Bengal winds ranged between east and north-east. Northerly winds prevailed at Balasore, and south-west winds at Gopalpore and False Point. The air was calm at 10 A. M. at Cuttack. Over North Bengal,

Behar, and Chutia Nagpore light easterly winds were blowing. The indraught to the vortex had diminished the humidity and cloud-amount considerably in North Bengal and Behar during the previous 24 hours, as shown by the following results :—

|                    | 10 A. M.<br>Average Humidity. |       | Average<br>Cloud Amount. |       |
|--------------------|-------------------------------|-------|--------------------------|-------|
|                    | 27th.                         | 28th. | 27th.                    | 28th. |
| North Bengal ..... | 81                            | 73    | 6·0                      | 4·0   |
| North Behar .....  | 79                            | 72    | 4·8                      | 3·2   |
| South Behar .....  | 80·5                          | 70·4  | 6·8                      | 4·4   |

The rainfall returns for the 24 hours previous to 6 P. M. indicate that moderate general rain had fallen over the whole of East and South-West Bengal, and that very heavy rain had been received in Orissa.

The following table gives the whole of the Orissa rainfall returns for the day :—

| District.      | Station.             | Rainfall. |
|----------------|----------------------|-----------|
| Pooree .....   | Pooree .....         | 0·59      |
|                | Khurdah .....        | 0·60      |
|                | Banpur .....         | nil.      |
|                | False Point .....    | 8·04      |
|                | Hookitola .....      | 3·68      |
| Cuttack .....  | Jagatsingapore ..... | 7·50      |
|                | Banki .....          | 0·35      |
|                | Cuttack .....        | 1·79      |
|                | Kendrapara .....     | 2·70      |
|                | Jaipur .....         | 2·80      |
| Balasore ..... | Chandbali .....      | 3·25      |
|                | Bhuddruck .....      | 1·78      |
|                | Sora .....           | 1·50      |
|                | Balasore .....       | 0·94      |
|                | Jellasore .....      | 3·40      |
|                | Baripoda .....       | 1·12      |

The weather on the Orissa coast is thus described by an observer :  
 “Thick heavy weather with heavy rain and overcast skies prevailed

during the day. At 4 p. m. it was blowing hard. Heavy rain fell all night with variable winds."

A few light showers fell in North Bengal and Chutia Nagpore, but rain had almost entirely ceased in Behar.

The following table gives the average rainfall throughout the Province of Bengal, and indicates clearly its distribution :—

| District.                                   | Average rainfall of previous 24 hours. | Heaviest rainfall in 24 hours. |
|---|--|--------------------------------|
| Orissa.....                                 | 2.50                                   | 8.04                           |
| South West Bengal .....                     | 0.15                                   | 0.76                           |
| East Bengal .....                           | 0.65                                   | 6.46                           |
| North Bengal .....                          | 0.17                                   | 1.25                           |
| North Behar.....                            | 0.03                                   | 0.30                           |
| South Behar.....                            | 0.01                                   | 0.10                           |
| Chutia Nagpur and }<br>Sonthal Pergunnahs } | 0.13                                   | 0.70                           |

The information respecting the weather in the Bay on the 28th June, extracted from the logs of the vessels, is given in the following statement :—

| Vessel.   | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable reduced<br>barometer. | Wind.    |        | REMARKS.                                    |
|-----------|---------|-----------------|------------------|--------------------------------|----------|--------|---|
|           |         |                 |                  |                                | Dir.     | Force. |   |
| Bancoora  | 4 A. M. |                 |                  | 29·653                         | S. W.    | 3      | Moderate breeze and puffy.                  |
|           | 8 A. M. |                 |                  | ·716                           | S. W.    | 3      | Overcast at times.                          |
|           | Noon    | 15° 08'         | 85° 33'          | ·683                           | S. W.    | 3      | Moderate following wind<br>and overcast.    |
|           | 4 P. M. |                 |                  | ·801                           | S. W.    | 3      | Moderate breeze and over-<br>cast.          |
|           | 8 P. M. |                 |                  | ·716                           | S. W.    | 3      | Moderate following wind<br>and fair.        |
|           | Midnt.  |                 |                  | ·671                           | S. W.    | 4      | Fresh breeze and cloudy.                    |
| Pemba ... | 4 A. M. |                 |                  |                                | S. S. W. | 9      | A. M. Strong gale with                      |
|           | 8 A. M. |                 |                  | 29·540                         | ...      | 9      | high sea and heavy                          |
|           | Noon    | 18° 34'         | 90° 59'          | ·540                           | ...      | 9      | squalls. Noon. A heavy                      |
|           | 4 P. M. | Rangoon to      |                  | ·460                           | ...      | 9      | sea smashed in the port                     |
|           | 8 P. M. | wards           | Sand             | ·500                           | ...      | 9      | bulwark rail forward of                     |
|           | Midnt.  | Heads.          |                  | ·520                           | ...      | 9      | bridge. Midnight. Very<br>high sea running. |

| Vessel.            | Hour.   | Latitude.<br>N. | Longitude.<br>E.   | Probable reduced<br>barometer. | Wind.                             |        | REMARKS.   |
|--------------------|---------|-----------------|--------------------|--------------------------------|-----------------------------------|--------|--|
|                    |         |                 |                    |                                | Dir.                              | Force. |  |
| Star of Albion ... | 8 A. M. |                 |                    | 29.500                         |                                   |        | Wind freshening, weather cloudy and threatening.   |
|                    | Noon    | 20° 14'         | 88° 23'            | .450                           | N. by W.                          | 5 to 8 | Continued lightning. Slight sea.   |
|                    | 4 P. M. |                 |                    | .440                           | W. N. W.                          |        | Latter part, strong gale with thick driving rain, and westerly sea.  |
|                    | 8 P. M. |                 |                    | .490                           |                                   |        |  |
|                    | Midnt.  |                 |                    | .470                           | West.                             |        |  |
| British Princess   | 4 A. M. |                 |                    |                                | N. W.                             | 7      | 4 A. M. Heavy rain, vivid lightning with thunder.  |
|                    | 8 A. M. |                 |                    |                                | ...                               | 7      | High confused sea. 8 A. M.   |
|                    |         |                 |                    |                                | ...                               | 8      | Heavy squall with torrents of rain. Moderate gale, high confused sea.  |
|                    | Noon    | 20° 46'         | 88° 7'             | 29.420                         | W. N. W.                          | 9      | Noon. Fresh gale, high confused sea. 4 P. M. Fresh gale, high sea, and heavy rain. 8 P. M. Heavy squalls, torrents of rain, high sea.  |
|                    | 4 P. M. |                 |                    |                                | West                              | 10     | Midnight. Furious squalls, torrents of rain, and high sea.   |
|                    | 8 P. M. |                 |                    |                                | S. W.                             | 10     |  |
|                    | Midnt.  |                 |                    |                                | ...                               | 11     |  |
| Scottish Chieftain | 4 A. M. |                 |                    | 29.400                         |                                   | 1      | Noon. Weather very unsteady, much rain, thunder and lightning. Very strong westerly current.   |
|                    | 8 A. M. |                 |                    | .300                           | N. N. W.                          | 2      | Sky presenting a very wild appearance.   |
|                    | Noon    | 20° 50'         | 88° 10'            | .250                           | ...                               | 3      |  |
|                    | 4 P. M. |                 |                    | .220                           | N. W.                             | 4      |  |
|                    | Midnt.  |                 |                    | .200                           | W.                                | 8      |  |
| Saint Magnus ..... | 4 A. M. |                 |                    | 29.330                         | N. W.                             | 6      | Heavy gusts and heavy continued rain.  |
|                    | 8 A. M. |                 |                    | .330                           |                                   |        | Strong winds and high sea.   |
|                    | Noon    | 20° 52'         | 88° 3'             | .290                           | N. W.                             | 4      | Winds and sea more moderate.   |
|                    | 4 P. M. |                 |                    | .260                           | W. S. W.                          | 6      | Terrific squalls. Tremendous sea at times.   |
|                    | 8 P. M. |                 |                    | .320                           | W. S. W.                          | 2      | Heavy sea, dense darkness.   |
|                    | Midnt.  |                 |                    | .300                           | S. W.                             | 10     | Furious gale, high squalls, heavy sea.   |
| Prince Amadeo      | 4 A. M. |                 |                    |                                | N. W.                             | Strong | Midnight. Boisterous squally weather with much heavy rain. 4 A. M. Squally weather, high southerly sea. Noon. Squally unsettled weather. 4 P. M. Weather more moderate. 6 P. M. Weather having a wild unsettled appearance. 8 P. M. Heavy squalls from W. S. W. to S. S. W. much rain. |
|                    | Noon    | Pilot bearing   | Brig N. E. 5 miles | 29.330                         | N. W. and                         |        |  |
|                    | 6 P. M. | about           |                    |                                | W. N. W. Variable between W. & S. |        |  |



| Vessel.  | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable reduced<br>barometer. | Wind.    |         | REMARKS.   |
|----------|---------|-----------------|------------------|--------------------------------|----------|---------|--|
|          |         |                 |                  |                                | Dir.     | Force.  |  |
| Commilla | 4 A. M. |                 |                  | 29·379                         | South    | 7       | 4 A. M. Very high sea from South and S. W. Breeze very variable in force with very hard squalls from S. S. W. and rain. 8 A. M. A very high sea running from S. S. W. Noon. Hard squalls from S. S. W. and very high sea from S. W. 4 P. M. Hard squalls from S. S. W. and very high sea from S. S. W. 6 P. M. Breeze very unsettled and hauling to N. W. at times. 6-30 P. M. Very heavy rain, tremendous sea from S. S. W. and S. W. 7 P. M. Eased down and stood S. by E. 7-30 P. M. Terrific sea carried away star-board cutter. 8 P. M. Terrific squalls from S. W. and very high sea. New jib and stay sail split. |
|          | 8 A. M. |                 |                  | ·317                           | S. S. W. | 7 to 4  |  |
|          | Noon    | 21° 04'         | 89° 31'          | ·277                           | S. S. W. | 6       |  |
|          | 4 P. M. |                 |                  | ·121                           | S. W.    | 8       |  |
|          | 6 P. M. |                 |                  |                                | Var.     | 6       |  |
|          | 8 P. M. |                 |                  | ·159                           | S. W.    | 9 to 10 |  |
|          | Midnt.  |                 |                  | ·182                           | S. W.    | 11      |  |
| Himalaya | 4 A. M. |                 |                  | 29·354                         | Variable |         | Fresh breeze and cloudy, with frequent rain squalls.   |
|          | 8 A. M. |                 |                  |                                | N.       |         |  |
|          | Noon    | 22° 32'         | 88° 20'          | ·264                           | N.       |         |  |
|          | 4 P. M. |                 |                  | ·354                           | N.       |         |  |
|          | 8 P. M. |                 |                  | ·449                           | N.       |         |  |
|          | Midnt.  |                 |                  | ·427                           | N.       |         |  |

The position of the centre of the barometric depression can be determined with approximate accuracy on the 28th. The observations at the Light Vessels show that it was in the immediate neighbourhood of the Sandheads at 10 A. M. It was hence very approximately in Lat. 21° 0' N. and in Long. 88° 45' E. The following table gives the barometric and wind observations taken at the Light Vessels and nearest

land stations, as well as the distance and direction of the centre (assuming this to be in the position assigned to it above) from each :—

|                                     | Position.       |                  | Barometer<br>10 A. M. | Wind 10 A. M. |           | Direction of<br>centre. | Distance from<br>probable posi-<br>tion of centre. | Weather, &c.              |
|-------------------------------------|-----------------|------------------|-----------------------|---------------|-----------|-------------------------|--|---------------------------|
|                                     | Latitude.<br>N. | Longitude.<br>E. |                       | Direction.    | Strength. |                         |  |                           |
| Saugor Island<br>Light House...     | 21° 39'         | 88° 5'           | 29·349                | N.N.E.        | Strong.   | S. E.                   | miles<br>63  | Gloomy.                   |
| Upper Gasper<br>Light Vessel...     | 21° 31'         | 88° 3'           | 29·327                | N. E.         | 5         | S. E.                   | 57   | Threatening<br>heavy sea. |
| Intermediate<br>Light Vessel...     | 21° 14'         | 88° 11'          | 29·241                | N.N.E.        | 4         | E.S.E.                  | 40   | Threatening.              |
| Eastern Channel<br>Light Vessel ... | 21° 0'          | 88° 12'          | 29·209                | N.N.E.        | 6         | E.                      | 35   | High sea.                 |
| Balasore .....                      | 21 30           | 86° 58'          | 29·364                | N.            | Light.    | E.S.E.                  | 130  | Threatening.              |
| False Point .....                   | 20° 20'         | 86° 47'          | 29·431                | W.S.W         | Moderate  | E.N.E.                  | 135  | Gloomy.                   |

The centre at this time was only at a distance of about 35 miles from two of the Light Vessels ; yet these were experiencing comparatively feeble winds, as compared with the strong gales blowing, as the log of the Pemba proves, at distances of 200 and 300 miles from the centre in the south-easterly quadrant.

The ships' logs do not give 10 A. M. observations. Their positions are given for noon, together with barometric readings and wind directions and force. When these are charted, they indicate the existence of a centre of depression in about Lat. 21° 3' N. and Long. 88° 40' E. The following table gives the positions of the ships at noon, and the distance and direction of the centre (assuming the position of this to be in Lat. 21° 3' N. and Long. 88° 40' E.) in each case.

|                           | Position at noon. |           | Barometer at Noon. | Wind (Noon). |                | Direction of centre. | Distance from probable position of centre at Noon. | Weather.                         |
|---------------------------|-------------------|-----------|--------------------|--------------|----------------|----------------------|--|----------------------------------|
|                           | Lat. N.           | Long. E.  |                    | Direction.   | Strength.      |                      |  |                                  |
| Saugor Island Light House | 21° 39'           | 88° 5'    | 29.311             | N. N. E.     | Light.         | S. E.                | 56   | Overcast.                        |
| Commillah ...             | 21° 04'           | 89° 31'   | 29.277             | S. S. W.     | 6              | W.                   | 54   | Hard squalls. Very high sea.     |
| Scottish Chieftain        | 20° 50'           | 88° 10'   | 29.250             | N. N. W.     | 3              | E. N. E.             | 35   | Unsettled.                       |
| Saint Magnus              | 20° 52'           | 88° 3'    | 29.290             | N. W.        | 4              | E. N. E.             | 42   | Strong wind. High sea.           |
| Prince Amadeo             | 20° 52'           | 88° 5' ?  | 29.330             | N. W.        | ...            | E. N. E.             | 40   | Squally. High sea.               |
| British Princess          | 20° 46'           | 88° 7' ?  | 29.420             | N. W.        | 8              | E. N. E.             | 43   | Heavy squalls High sea.          |
| Star of Albion            | 20° 14' ?         | 88° 23' ? | 29.450             | N. by W.     | 5              | N. N. E.             | ?  | Threatening weather. Slight sea. |
| Pemba .....               | 18° 34'           | 90° 59'   | ...                | S. S. W.     | 9              | N. W.                | 225  | Strong gale. Heavy sea.          |
| False Point ...           | 20° 20'           | 86° 47'   | 29.309             | W. S. W.     | Mod-<br>erate. | E. N. E.             | 125  | Overcast.                        |

In examining the above, it should be remembered that the positions assigned to the Commillah, Scottish Chieftain, Saint Magnus, and Star of Albion were determined by observation at noon, and hence are assumed to be approximately correct. The position of the Prince Amadeo is stated to have been a few miles to the S. W. of the Pilot Brig. The position given has been determined from that statement on the assumption that the station for the Pilot Vessels during the S. W. monsoon, is at a distance of from 7 to 10 miles to the south or south-west of the Eastern Channel Light Vessel (*vide* Elson's Sandheads Sailing Directory, page 156); and is probably correct within five or six miles. The position of the British Princess at noon was ascertained by dead reckoning, and is certainly not correct, as all the vessels had drifted considerably with the currents now set up at the Head of the Bay. The noon observations of the barometer and wind direction indicate that she was probably in about Lat. 20° 55' and Long. 87° 45'.

The preceding table confirms much of the information given by the Light Vessels. The winds in the western quadrant, at distances of 30 to 50 miles from the centre, were very light and unsteady in force, as compared with those in the eastern quadrant. The barometric observations,

when charted, shew that the depression, as defined by the isobar of 29·3", was an elliptical shaped area at the centre of which the pressure probably did not exceed 29·2". The larger axis of this stretched E. N. E. and W. S. W., and was probably at least twice as long as the axis at right angles to it.

The observations taken on board the Light Vessels at 4 P. M. also enable the centre to be approximately determined at that hour. When charted, they indicate that the centre was in about Lat. 21° 10' N. and Long. 88° 30' E.

The following table shows that this gives consistent results for the direction and distance of the centre from each position :—

|  | Position.  |             | Baro-<br>meter. | Wind.      |                | Direction<br>of<br>centre. | Distance from<br>probable position<br>of centre. | Weather,<br>&c.              |
|--|------------|-------------|-----------------|------------|----------------|----------------------------|--|------------------------------|
|  | Lat.<br>N. | Long.<br>E. |                 | Direction. | Strength.      |                            |  |                              |
| Saugor Island<br>Light House               | 21° 39'    | 88° 5'      | 29·270          | N. N. E.   | Mode-<br>rate. | S. E.                      | 43   | Overcast.                    |
| Upper Gasper<br>Light Vessel               | 21° 31'    | 88° 3'      | 29·215          | N. E.      | 5              | S. E.                      | 38   | Heavy<br>sea.                |
| Intermediate<br>Light Vessel               | 21° 15'    | 88° 11'     | 29·155          | N.         | 4              | E. S. E.                   | 21   | Threa-<br>tening<br>weather. |
| Eastern Chan-<br>nel Light<br>Vessel ..... | 21° 1'     | 88° 12'     | 29·142          | N. W.      | 5 to 8         | E. N. E.                   | 23   | High sea<br>from<br>S. W.    |
| False Point<br>Light House                 | 20° 20'    | 86° 47'     | 29·301          | W. S. W.   | strong.        | E. N. E.                   | 125  | Overcast.                    |

These observations also show the weakness of the winds in the western quadrant. The Intermediate Light Vessel, although only 21 miles distant from the centre, experienced winds of force 4 at this time, whilst the Pemba, about 200 miles to the south-east, had winds of force 9 to 10.

Hence, the path of the centre during the day is determined by the positions given in the following table :—

| Hour.         | Latitude.  | Longitude. |
|---------------|------------|------------|
| 10 A. M. .... | 21° 0' N.  | 88° 45' E. |
| Noon .....    | 21° 3' N.  | 88° 40' E. |
| 4 P. M. ....  | 21° 10' N. | 88° 30' E. |



The character of the weather is fully shown by the reports given in the logs. Two vessels, the *Commillah* and *Pemba*, were in the east and south-east quadrants, in which alone the winds were violent. The *Pemba* was in Lat.  $18^{\circ} 14' N.$  and Long.  $90^{\circ} 59' E.$  by account at noon. She experienced strong S. S. W. gales during the whole day, with a high sea, and heavy rain squalls. A heavy sea smashed in her port bulwark rails early in the morning, after which the Captain eased the engines, and laid to, with the ship's head to S. S. E.; during the greater part of the afternoon. The *Commilla*, which was proceeding from Chittagong to Calcutta, did not feel the full weight of the south-westerly winds until the afternoon, when she was between the Mutlah station and the Sandheads. She experienced, early in the morning, winds varying very considerably in force, with occasional hard squalls from S. S. W., and much rain. During the whole of the afternoon, she had very hard squalls with heavy rain, and a tremendous sea. At 7-20 P. M. a terrific sea carried away the starboard cutter. This was followed by very violent squalls of force 11 from the south-west.

The position of the British *Princess* was not ascertained by observation during the day, and it is almost certain that she must have drifted considerably with the strong currents set up at this time in the Head of the Bay. She was in the south-western quadrant in the morning, and had heavy rain with a high confused sea. The rainfall increased early in the morning, and during the greater part of the day she had "torrents of rain." The squalls also became heavier as the day advanced, and at midnight furious squalls (force 11) from the south-west passed over the vessel.

The *Saint Magnus* was in the western quadrant in the morning, when she had north-westerly winds of force 4 to 6. Heavy gusts of wind passed over the vessel, and continuous rain fell during the whole morning. In the evening, she was in the southerly quadrant, where she began to experience terrific squalls with a tremendous sea. At midnight, it was blowing a furious gale (force 10) from the south-west.

Hence, over a large area to the east and south-east of the central depression, violent south-westerly winds of force 9 to 11 were blowing at this time, producing a very high and dangerous sea near the Head of the Bay.

Further south, as shewn by the log of the *Bancoora*, the winds in the centre of the Bay (Lat.  $15^{\circ} N.$ , Long.  $83^{\circ} E.$ ) were of moderate force and gave very faint indications of the action and disturbance to the northward.

The *Star of Albion*, *Roma*, *Prince Amadeo*, and *Scottish Chieftain* were to the west of the centre of the whirl during the greater part of the day. The *Scottish Chieftain* was probably nearest to it at noon.

The position of the *Star of Albion* is doubtful. The weather was threatening in the morning, and the winds shifted from north through north-west to west in the evening, increasing in force during the day. In the afternoon and evening, as the wind backed to west, a strong gale set in with thick driving rain.

The *Scottish Chieftain* was in Lat.  $20^{\circ} 50'$  N. and Long.  $88^{\circ} 10'$  E. at noon. The winds were light during the morning; much rain fell, but it was not until midnight, when the wind hauled to west, that she began to have strong winds and rain squalls.

The *Prince Amadeo* was near the Pilot Station and to the west of the centre. Boisterous squalls with heavy rain and a high sea were experienced during the morning. In the evening, the weather had a very wild appearance. The wind shifted round to the south-west, and heavy squalls passed over the vessel, bringing up much rain.

The Light Vessels were all in the western quadrant during the day.

The Captain of the *Meteor* (Intermediate station) states that the winds were changeable between north and west, and that frequent heavy showers occurred during the day.

The Captain of the *Comet* (Upper Gasper Station) notes that the weather appeared very wild. Squalls with rain passed over the vessel, and a very heavy sea came up from the south-east.

*29th June.*—The changes of the barometer over India during the preceding 24 hours were partly due to the further development of the depression and cyclonic disturbance off the coast of the Sunderbunds, and partly to the appearance of a depression off the west coast.

The barometer at Saugor Island had fallen two tenths of an inch since 10 A. M. of the 28th, and by considerable amounts at all the Lower Bengal stations. It had risen in the surrounding districts, so that the differences of pressure had become considerably greater and the depression very marked. The disturbance was now giving strong easterly winds, with overcast skies and moderate rain, to East and South Bengal, and strong northerly and westerly winds and incessant rain to Orissa.

The barometer had also fallen considerably at Kurrachee, where very strong N. E. winds were blowing. The wind had backed from west to south-west along the Bombay coast, thus almost certainly indicating the appearance or formation of a depression off the west coast.

Over the Gangetic plain and the western Himalayas, variable winds obtained, with cloudy weather and light rain.

The following table gives the observations at the selected stations in the neighbourhood of the Bengal depression :—

| STATIONS.                     | Barometer at<br>10 A. M. reduced<br>to sea level. | Change<br>since<br>yesterday. | Wind.    |          | Average wind<br>velocity of previ-<br>ous 24 hours. | Percentage wind. | 10 A. M. Cloud. | Rainfall<br>of<br>previous<br>24 hours. |
|-------------------------------|---|-------------------------------|----------|----------|---|------------------|-----------------|---|
|                               |   |                               | 10 h.    | 16 h.    |   |                  |                 |   |
| Nancowry .....                | 29·914  | + ·001                        | S. W.    | S. W.    | 8   | 73               | 7               | 2·21                                    |
| Port Blair .....              | 29·875  | + ·019                        | S. W.    | S. W.    | 13  | 118              | 5               | 0·20                                    |
| Diamond Island                | 29·835  | + ·028                        | S. S. W. | S. S. W. | 13  | 163              | 8               | 0·40                                    |
| Akyab .....                   | 29·695  | + ·056                        | S. S. E. | S. S. E. | 11  | 275              | 7               | 1·43                                    |
| Chittagong ...                | 29·608  | + ·037                        | S. E.    | E.       | 11  | 157              | 10              | 2·31                                    |
| Dacca .....                   | 29·530  | + ·004                        | E.       | E.       | 13  | 163              | 10              | 0·26                                    |
| Jessore .....                 | 29·445  | 0                             | E.       | E.       | 18  | 360              | 10              | 0·78                                    |
| Calcutta (Ali-<br>pore) ..... | 29·322  | — ·070                        | E.       | E.       | 19  | 317              | 10              | 0·64                                    |
| Saugor Island                 | 29·173  | — ·201                        | E.       | S. W.    | 26  | 186              | 10              | ...                                     |
| Balasore .....                | 29·355  | — ·068                        | N. N. W. | ?        | 8   | ?                | 10              | 1·22                                    |
| Cuttack .....                 | 29·463  | — ·044                        | N. W.    | W. N. W. | 6   | 150              | 10              | 3·83                                    |
| False Point ...               | 29·440  | — ·012                        | W. S. W. | W. S. W. | 23  | 230              | 10              | 8·22                                    |
| Vizagapatam...                | 29·613  | — ·001                        | S. W.    | W. by N. | 6   | 150              | 10              | ...                                     |

The meteorological returns of the Bengal stations show that a large fall of the barometer had occurred in South-West Bengal and Orissa, whilst, over the remainder of the province, a considerable recovery of pressure was taking place. The depression off Saugor Island was now unusually large in amount, and such as is rarely observed in the rainy season. Pressure was below the normal of the day at all stations, by amounts varying between ·01" at Durbhunga and ·45" at Saugor Island. The atmospheric circulation in Bengal was now directly dependent on the cyclonic vortex off the coast of the Sunderbands, and winds were very strong in the neighbourhood of the vortex in South-West Bengal, Orissa, and Chutia Nagpore. The winds in Chutia Nagpore and South Behar at 10 A. M. were from directions between E. N. E. and N. N. E. In North Bengal and Behar the winds were from the east, the normal direction during the south-west monsoon.

The air was now almost saturated in East and South-West Bengal and Orissa. Humidity had also increased very considerably over the

remainder of the Province, more especially in South Behar and Chutia Nagpore. The skies were overcast, or densely clouded, in all parts of the Province, except North Bengal and Behar.

Orissa again received very heavy rain. The following table gives the amounts recorded at all the reporting stations during the 24 hours preceding 6 P. M. of this day :—

| District.      | Stations.            | Rainfall. |
|----------------|----------------------|-----------|
| Pooree.....    | Pooree .....         | 9·44      |
|                | Khurdah .....        | 7·96      |
|                | Bampur .....         | 3·46      |
|                | False Point .....    | 5·39      |
|                | Hookitola.....       | 4·48      |
| Cuttack .....  | Jagatsingapore ..... | 4·90      |
|                | Banki .....          | 6·40      |
|                | Cuttack .....        | 5·61      |
|                | Kendrapara .....     | 3·60      |
|                | Jajpore .....        | 1·98      |
| Balasore ..... | Chandbali.....       | 4·15      |
|                | Bhuddruck .....      | 0·93      |
|                | Sora .....           | 1·60      |
|                | Balasore .....       | 2·65      |
|                | Jellasore .....      | 5·00      |
|                | Baripoda .....       | 1·60      |

General rain, moderate to heavy in amount, fell in East Bengal, South-West Bengal, and Chutia Nagpore, and local showers in North Bengal. No rain of any importance fell in Behar.

The following table gives the average rainfall for the preceding 24 hours in the various divisions of the Province of Bengal, and indicates the distribution at this time :—

*Rainfall Table of the 29th June, 1883.*

| Division.                                   | Number of stations in each province. | Average rainfall of 24 hours. | Heaviest fall in 24 hours. |
|---|--------------------------------------|-------------------------------|----------------------------|
| Orissa.....                                 | 16                                   | 4·32                          | 9·44                       |
| South-West Bengal.....                      | 46                                   | 0·65                          | 3·76                       |
| East Bengal .....                           | 26                                   | 1·59                          | 5·50                       |
| North Bengal .....                          | 27                                   | 0·24                          | 2·97                       |
| North Behar .....                           | 16                                   | 0·03                          | 0·25                       |
| South Behar .....                           | 17                                   | ...                           | 0·02                       |
| Sonthal Pergannahs and Chutia Nagpore ..... | 16                                   | 0·25                          | 1·54                       |



| Vessel.         | Hour.   | Latitude.<br>N.           | Longitude.<br>E. | Probable<br>re-<br>duced<br>baro-<br>meter. | Wind.           |         | REMARKS.  |
|-----------------|---------|---------------------------|------------------|---|-----------------|---------|---|
|                 |         |                           |                  |   | Direc-<br>tion. | Force.  |   |
| Bancoora        | 4 A. M. |                           |                  | 29.597                                      | S. W.           | 5       | Strong increasing breeze and puffy.   |
|                 | 8 A. M. |                           |                  | .666  | S. W.           | 5       | Lightning in N. W.  |
|                 | Noon    | 18° 40'                   | 86° 58'          | .666  | S. W.           | 5       | Strong unsteady wind and squally.   |
|                 | 4 P. M. |                           |                  | .517  | S. W.           | 6       | Strong breeze and squally.  |
|                 | 8 P. M. |                           |                  | .517  | S. W.           | 4       | Fresh following wind and overcast.  |
|                 | Midnt.  |                           |                  | .495  | S. W.           | 5       | Strong breeze with hard squalls throughout.   |
| Pemba ...       | 4 A. M. |                           |                  | 29.420                                      | S. W.           | 10      | A. M. Fierce gale with high irregular sea and hard squalls blowing with hurricane violence. 1 A. M. Kept away course again  |
|                 | 8 A. M. |                           |                  | .470  | W. S. W.        | 10      | (N. 51 W.) 5 A. M. Lay to again. 9 A. M. Kept away course again, sea breaking over the ship fore and aft. 9-15 A. M. Laid to. 0.30 P. M. Course again. 3 P. M. Hauled to the wind again. 5 P. M. Kept away course again. 10-20 P. M. Sea becoming confused; weather inclined to moderate, sky clearing. |
|                 | Noon    | 19° 16'                   | 89° 56'          | .500  | S. W.           | 9       |   |
|                 | 4 P. M. | Rangoon towards Calcutta. |                  | .450  | ...             | 9       |   |
|                 | 8 P. M. |                           |                  | .500  | ...             | 9       |   |
|                 | Midnt.  |                           |                  | .530  | ...             | 7       |   |
| Star of Albion. | 8 A. M. |                           |                  | 29.520                                      | W. S. W.        |         | Hard gale and heavy sea, thick continued rain.  |
|                 | Noon    | 19° 43'                   | 88° 37'          | .530  | S. W.           | 9 to 10 |   |
|                 | 4 P. M. |                           |                  | .520  |                 |         |   |
|                 | 8 P. M. |                           |                  | .570  |                 | 9 to 10 |   |
|                 | Midnt.  |                           |                  | .550  | S. W.           |         | Weather, more moderate and less rain.   |
| Saint Magnus.   | 4 A. M. |                           |                  | 29.230                                      | W. S. W.        | 10      | Heavy gale with terrific gusts, heavy sea, and continued heavy rain.  |
|                 | 8 A. M. |                           |                  | .300  | W. S. W.        | 10      |   |
|                 | Noon    | 19° 58'                   | 88° 28'          | .370  | W. S. W.        | 10      | Heavy squalls, rain, and high sea.  |
|                 | 4 P. M. |                           |                  | .380  | S. S. W.        | 9       |   |
|                 | 8 P. M. |                           |                  | .430  | S. S. W.        | 8       | Dirty appearance and heavy gusts.   |
|                 | Midnt.  |                           |                  | .340  | S. S. W.        | 8       |   |

| Vessel.               | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable<br>re-<br>duced baro-<br>meter. | Wind.             |        | REMARKS.  |
|-----------------------|---------|-----------------|------------------|--|-------------------|--------|---|
|                       |         |                 |                  |  | Direc-<br>tion.   | Force. |   |
| Prince<br>Amadeo.     | 4 A. M. |                 |                  |  | W. to<br>S. S. W. | 8      | Morning. Strong gale,<br>furious squalls.<br>Sharp vivid light-<br>ning, wild unsettled<br>appearance. Noon.<br>Strong gale, heavy<br>squalls, sea high and<br>very confused. Even-<br>ing. Similar wind<br>and weather.  |
|                       | Noon    | 20° 00'         | 88° 55'          | 29.320                                   | S. W.             | to     |   |
|                       | Midnt.  |                 |                  |  | S. W.             | 10     |   |
| Commilla              | 4 A. M. |                 |                  | 29.190                                   | S. W.             | 11     | 4 A. M. Terrific storm,<br>continual rain, and<br>furious squalls. 8 A. M.<br>Squalls of hurricane<br>force. Mountainous<br>sea. Noon. Very high<br>and dangerous sea<br>running; both an-<br>chors lifted out of<br>catchhooks, breaking<br>one stock. 4 P. M.<br>Wind and sea<br>slightly moderating.<br>Violent squalls from<br>S. W. 8 P. M. Sky<br>overhead clearing<br>at times; very dark<br>wild squally wea-<br>ther. Very heavy<br>rain in the squalls. |
|                       | 8 A. M. |                 |                  | .247                                     | S. W.             | 11     |   |
|                       | Noon    | 20° 18'         | 88° 40'          | .252                                     | S. W.             | 11     |   |
|                       | 4 P. M. |                 |                  | .232                                     | S. W.             | 10     |   |
|                       | 8 P. M. |                 |                  | .237                                     | S. W.             | 10     |   |
|                       | Midnt.  |                 |                  | .234                                     | S. W.             | 10     |   |
| British<br>Princess   | 4 A. M. |                 |                  |  | S. W. by S.       | 11     | Torrents of rain.<br>High confused sea.   |
|                       | 8 A. M. |                 |                  |  |                   | 10     |   |
|                       | Noon    | 20° 24'         | 88° 42'          | 29.340                                   |                   | 10     | Westerly gale.<br><br>Sea very high.  |
|                       | 4 P. M. |                 |                  |  |                   | 10     |   |
|                       | 8 P. M. |                 |                  |  | S. W.             | 9      |   |
|                       | Midnt.  |                 |                  |  | ...               | 9      |   |
| Scottish<br>Chieftain | 4 A. M. |                 |                  |  | W. S. W.          | 10     | Lost fore topsail, laid<br>ship to under close<br>reefed main topsail.  |
|                       | 8 A. M. |                 |                  | 29.250                                   | ...               | 11     |   |
|                       | Noon    | 20° 40'         | 88° 10'          | .300                                     | ...               | 10     |   |
|                       | 4 P. M. |                 |                  | .350                                     | ...               | 8      |   |
|                       | 8 P. M. |                 |                  |  | ...               | 6      | Heavy rain and con-<br>fused sea. Very<br>strong westerly cur-<br>rent.   |
|                       | Midnt.  |                 |                  | .400                                     | S. W.             | 6      |   |

The various observations enable the centre of the barometric depression to be determined very approximately at 10 A. M. and at noon of the 29th. The wind directions at 10 A. M. observed on board the Light Vessels at the Upper Gasper and Intermediate stations were south-east and west, and hence the centre was between these vessels. Its position as determined by charting the wind directions and barometric heights was Lat.  $21^{\circ} 30'$  N. and Long.  $87^{\circ} 55'$  E.

The following table gives the chief observations taken at the light vessels and neighbouring land stations at 10 A. M., and the distance and bearing of the centre from each of them.

|                               | Position.        |                  | Barometer. | Winds.     |           | Direction of centre. | Distance from probable position of centre. |
|-------------------------------|------------------|------------------|------------|------------|-----------|----------------------|--|
|                               | Latitude.<br>N.  | Longitude.<br>E. |            | Direction. | Strength. |                      |  |
| Sangor Island Light House.    | $21^{\circ} 39'$ | $88^{\circ} 5'$  | 29.146     | E.         | Moderate. | S. W.                | 14   |
| Upper Gasper Light Vessel.    | $21^{\circ} 31'$ | $88^{\circ} 3'$  | 29.140     | S. E.      | 5         | W.                   | 8  |
| Intermediate Light Vessel.    | $21^{\circ} 15'$ | $88^{\circ} 11'$ | 29.164     | W.         | 6         | N. W.                | 24   |
| Eastern Channel Light Vessel. | $21^{\circ} 1'$  | $88^{\circ} 12'$ | 29.199     | W. S. W.   | 8 to 9    | N. W.                | 38   |
| Balasore .....                | $21^{\circ} 30'$ | $86^{\circ} 58'$ | 29.296     | N. N. W.   | 8         | E.                   | 60   |
| False Point .....             | $20^{\circ} 20'$ | $86^{\circ} 47'$ | 29.419     | W. S. W.   | Strong    | N. E.                | 110  |

The nearest light-vessels were between 5 and 25 miles from the centre in the eastern quadrant, and yet experienced very moderate winds of force 5 to 6, whilst the Pemba and Commillah, at much greater distances in the same quadrant, had winds of force 9 to 11.

The unusual weakness of the winds in all quadrants near the centre, as compared with those in the south-eastern quadrant at considerable distances from the centre, is a remarkable fact, and one that is opposed to the general experience of cyclonic motion.

The noon barometric readings and wind directions of the ships, when charted, indicate that the centre was at that hour probably in Lat.  $21^{\circ} 30'$  N. and Long.  $87^{\circ} 50'$  E. It had moved about five miles to the west during the previous two hours.

The following table gives the distance and bearing of the centre from each of the vessels at that hour :—

|                            | Position.       |                  | Barometer. | Wind.          |           | Direction of centre. | Distance from probable position of centre. |
|----------------------------|-----------------|------------------|------------|----------------|-----------|----------------------|--|
|                            | Latitude.<br>N. | Longitude.<br>E. |            | Direction.     | Strength. |                      |  |
| Saugor Island Light House. | 21° 39'         | 88° 5'           | 29.146     | E.             | Moderate. | S. W.                | 19   |
| Commillah .....            | 20° 18'         | 88° 40'          | 29.252     | S. W.          | 11        | N. W.                | 100  |
| Scottish Chieftain         | 20° 40'         | 88° 10'          | 29.300     | W. S. W.       | 10        | N. N. W.             | 60   |
| Saint Magnus .....         | 19° 58'         | 88° 28'          | 29.370     | W. S. W.       | 10        | N. N. W.             | 115  |
| British Princess...        | 20° 24'         | 88° 42'          | 29.340     | S. W. by S.    | 10        | N. W.                | 95   |
| Prince Amadeo.....         | 20° 00'         | 88° 55'          | 29.320     | W. to S. S. W. | 8 to 10   | N. W.                | 125  |
| Star of Albion .....       | 19° 43'         | 88° 37'          | 29.53      | S. W.          | 9 to 10   | N. N. W.             | 145  |
| Pemba .....                | 19° 16'         | 89° 56'          | 29.50      | S. W.          | 9         | N. W.                | 200  |

The preceding table shows that the vessels were all in the south eastern quadrant. They were experiencing violent west to south-west winds with frequent squalls of hurricane force. The majority of them were for the first time feeling the full strength of the storm.

The storm continued to pass to the westward during the day. The centre was probably in Lat. 21° 35' N. and Long. 87° 30' E. at 4 P. M.

The observations taken at the light-vessels and the neighbouring land stations, with the probable distance and bearing of the centre from each, are given below :—

|                               | Position.       |                  | Barometer. | Wind.       |             | Direction of centre. | Distance from probable position of centre. |
|-------------------------------|-----------------|------------------|------------|-------------|-------------|----------------------|--|
|                               | Latitude.<br>N. | Longitude.<br>E. |            | Direction.  | Strength.   |                      |  |
| Calcutta (Alipore).           | 22° 32'         | 88° 20'          | 29.214     | E.          | Strong      | S. S. W.             | 85   |
| Burdwan .....                 | 23° 14'         | 87° 54'          | 29.245     | N. E.       | Light       | S. W.                | 115  |
| False Point .....             | 20° 20'         | 86° 47'          | 29.361     | W. S. W.    | Strong      | N. N. E.             | 98   |
| Cuttack .....                 | 20° 29'         | 85° 54'          | 29.285     | W. N. W.    | Light       | N. E.                | 130  |
| Saugor Island Light House.    | 21° 39'         | 88° 5'           | 29.112     | S. W.       | Very strong | W.                   | 38   |
| Upper Gasper Light Vessel.    | 21° 31'         | 88° 3'           | 29.108     | S. W.       | 9           | W.                   | 36   |
| Intermediate Light Vessel.    | 21° 15'         | 88° 11'          | 29.199     | S. W.       | 9           | W. N. W.             | 50   |
| Eastern Channel Light Vessel. | 21° 1'          | 88° 12'          | 29.237     | S. W. by W. | 8 to 9      | W. N. W.             | 60   |



The preceding observations show that the light-vessels were now experiencing very strong south-westerly winds, and that frequent severe squalls passed over them.

The remarkable difference between the force of the south-westerly winds at distances of more than 30 miles from the centre and the winds from other directions and also the winds near the centre, is shown very conclusively by the Saugor Island observations. The greatest amount of wind, as registered by the anemometer at that station in any interval of two hours between 1 P. M. of the 28th and 3 P. M. of the 29th, was 23 miles. The amount recorded between 1 P. M. and 3 P. M. of the 29th, when very variable unsteady winds were blowing, was only 5 miles. Between 3 P. M. and 5 P. M., during which hours south-west winds prevailed, 78 miles of wind were recorded, and between 5 P. M. and 7 P. M., 46 miles. During this period, a severe gale of wind blew from the south, and gave rise to a tremendous sea.

The position of the centre has been deduced from the various observations. It moved during the day almost due westwards, parallel to the coast of the Sunderbunds. The vessels bound for Calcutta, which were approaching the entrance to the Hooghly, were almost without exception in the eastern quadrant during the day. Their logs describe the force of the south-westerly winds in this part of the whirl in very similar language.

The Commillah, in Lat.  $20^{\circ} 18'$  N. Long.  $88^{\circ} 40'$  E. at noon, had terrific gales, with continual rain and furious squalls, in the morning. Squalls of hurricane force passed over the steamer. A tremendous and dangerous sea was running. South-westerly winds of average force 11 obtained during the morning. The wind and weather slightly moderated during the afternoon, but violent squalls continued to come up from the south-west, bringing very heavy rain.

The Pemba, 100 miles to the S. E. of the Commillah, experienced a fierce gale with hard squalls blowing with hurricane violence. No improvement occurred in the weather until late in the evening, when the sky began to clear and the sea to moderate a little.

The Star of Albion and the Scottish Chieftain experienced similar weather. The log of the Saint Magnus (in Lat.  $19^{\circ} 58'$  N. Long.  $88^{\circ} 28'$  E. at noon) describes the weather in the morning as a heavy gale with terrific gusts and continued heavy rain. The Captain of the British Princess (in Lat.  $20^{\circ} 24'$  N. and Long.  $88^{\circ} 42'$  E. at noon) notes that the wind decreased from force 11 in the morning to force 9 in the evening, and that torrents of rain fell during the morning. The wind blew steadily from the south-west quarter, and brought up a very high sea.

The Captain of the Comet speaks as follows of the weather on the 29th: "Weather was very threatening. A heavy sea came up from the south-east; the wind was very variable, shifting all round the compass. Rain squalls frequently came up. At midnight it was blowing a furious gale."

The Captain of the Meteor remarks of the weather he experienced during the day: "The sea was very rough and a high squall from south-west came up at 8 A. M. Frequent heavy rain-squalls passed over the vessel. The wind shifted to south-west at 10.30 A. M. The barometer began to rise at 2 P. M. During the evening a strong south-west gale blew, and frequent terrific rain-squalls passed over the vessel. At 11 P. M. the wind began to decrease in force and the squalls were less frequent."

30th June.—The depression off the mouth of the Hooghly on the 29th had travelled in a westerly direction, crossed the coast near Balasore, and passed westward to the north of Cuttack.

The depression was apparently smaller than on the previous day, the lowest recorded reading of the barometer at 10 A. M. being 29.35". It was, however, a well-marked depression of about a quarter of an inch at the centre. The westward motion of the disturbance caused the barometer to fall briskly at Cuttack and in the adjacent districts of Chutia Nagpore and the Central Provinces, whilst, over the whole of Bengal, a very rapid recovery of pressure occurred. The wind directions in North-Eastern India indicated the continuance of cyclonic circulation in Bengal, Orissa, the Central Provinces, and Chutia Nagpore. Winds were from west in Orissa, south to east in Bengal, north in Chutia Nagpore, and north-west in the Central Provinces.

In other parts of India, the barometer rose generally during the preceding 24 hours. The changes over the greater part of the North Western Provinces and Bombay slightly exceeded a tenth of an inch, but the relative distribution of pressure was unaltered, except in Bengal and Orissa. The wind on the Bombay Coast had veered again to south-west, and was moderating. Very cloudy skies prevailed over the whole of Northern India. Heavy rain showers had fallen in the North-Western Provinces, and diminished the temperature over a large portion of Upper India from 10° to 15°.

Heavy rain continued to fall in connection with the cyclonic vortex in Orissa and the western districts of the Central Provinces.

The preceding remarks are illustrated by the following observations:—

| STATIONS.           | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind.    |          | Wind velocity in miles per hour since 10 A. M. previous day. | Percentage wind. | Cloud 10 A. M. | Rainfall at 10 A. M. of preceding 24 hours. |
|---------------------|---|-------------------------------------|----------|----------|--|------------------|----------------|---|
|                     |   |                                     | 10 h.    | 16 h.    |  |                  |                |   |
| Nancowry .....      | 29·912                                      | —·002                               | S. W.    | S. S. W. | 10   | 91               | 8              | ...   |
| Port Blair .....    | 29·846                                      | —·029                               | S. W.    | S. W.    | 12   | 109              | 4              | ...   |
| Diamond Island ...  | 29·832                                      | —·003                               | S. S. W. | S. W.    | 9  | 113              | 5              | ...   |
| Akyab .....         | 29·776                                      | +·081                               | S. S. E. | S.       | 7  | 175              | 7              | 2·75  |
| Chittagong .....    | 29·758                                      | +·150                               | E.       | E.       | 9  | 129              | 10             | 2·25  |
| Dacca .....         | 29·684                                      | +·154                               | S. E.    | S.       | 12   | 150              | 10             | 0·24  |
| Jessore .....       | 29·645                                      | +·200                               | E. S. E. | S. E.    | 21   | 420              | 10             | 0·29  |
| Calcutta (Alipore)  | 29·555                                      | +·233                               | S. E.    | S. S. E. | 16   | 267              | 10             | 1·17  |
| Saugor Island ..... | 29·517                                      | +·344                               | S. E.    | S. E.    | 19   | 136              | 10             | 0·36  |
| Balasore .....      | 29·433                                      | +·078                               | S.       | ?        | 14   | ?                | 10             | 7·37  |
| Cuttack .....       | 29·382                                      | —·086                               | W.       | W. N. W. | 10   | 250              | 10             | 4·08  |
| False Point .....   | 29·444                                      | +·004                               | S.       | S.       | 24   | 240              | 9              | 1·47  |
| Vizagapatam .....   | 29·618                                      | +·005                               | W.       | W. by S. | 6  | 150              | 10             | ...   |

The following observations taken at stations in and near the area of cyclonic disturbance on the morning (10 A. M.) of 30th June give data for the determination of the storm centre at that hour:—

| STATION.            | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind.              |   | Cloud amount at 10 A. M. | Rainfall at 10 A. M. of preceding 24 hours. |
|---------------------|---|-------------------------------------|--------------------|---|--------------------------|---|
|                     |   |                                     | Direction 10 A. M. | Amount in miles per hour since 10 A. M. previous day. |                          |   |
| Saugor Island ..... | 29·517                                      | +·344                               | S. E.              | 19·0  | 10                       | 0·36  |
| Calcutta .....      | 29·556                                      | +·233                               | S. E.              | 16·0  | 10                       | 1·17  |
| Burdwan .....       | 29·546                                      | +·121                               | E.                 | 12·0  | 10                       | 0·88  |
| Hazaribagh .....    | 29·518                                      | —·027                               | E. N. E.           | 18·0  | 10                       | 0·38  |
| Jubbulpore .....    | 29·686                                      | +·042                               | W. N. W.           | 6·0   | 10                       | 0·45  |
| Seoni .....         | 29·665                                      | +·002                               | N. W.              | 5·0   | 6                        | 0·45  |
| Nagpur .....        | 29·674                                      | +·017                               | N. W.              | 9·0   | 10                       | ...   |
| Raipore .....       | 29·512                                      | —·087                               | W.                 | 20·8  | 10                       | 1·28  |
| Sambalpore .....    | 29·353                                      | —·111                               | S. W.              | 3·3   | 10                       | 4·74  |
| Cuttack .....       | 29·382                                      | —·086                               | W.                 | 10·0  | 10                       | 4·08  |
| False Point .....   | 29·444                                      | +·004                               | S.                 | 24·0  | 9                        | 1·47  |



The observations indicate that the cyclonic area extended over Orissa and the north-eastern districts of the Central Provinces, and that the centre was in the neighbourhood of Sambalpore and to the north-west. The probable position of the centre at 10 A. M. was Lat.  $21^{\circ} 45'$  N. and Long.  $83^{\circ} 50'$  E.; and the barometric height there was almost certainly not lower than 29.3". It had consequently crossed over the Northern Orissa Hills (in the Hill States of Morbhanj, Keunjhar, and Pal Lahara), the average height of which appear to be about 2000 ft., and the highest points of which slightly exceed 3,500 ft. This area is described in the following language by Dr. Hunter in his Statistical Account of the Orissa States :—"From the north bank of the Mahanadi, the ranges tower into a fine watershed, from 2000 to 2500 feet high, running north-west and south-east, and forming the boundary of the States of Nursingpore and Baramba. On the other side, they slope down upon the States of Hindol and Dhenkanal supplying countless little feeders to the Brahmani, which occupies the second of the three valleys. From the north bank of this river, the hills again roll back into magnificent ranges, running in the same general direction as before, but more confused and wilder, till they rise into the Keunjhar watershed, with peaks from 2500 to 3500 feet high, culminating in Malayagiri, 3,895 feet high, in the State of Pal Lahara. This watershed, in turn, slopes down into the third valley, that of the Baitarani, from whose eastern or left bank rise the hitherto almost unexplored mountains of Morbhanj, heaped upon each other in noble masses of rock, from 3,000 to nearly 4,000 feet high, sending countless tributaries to the Baitarani on the south, and pouring down the Burabalang, with the feeders of the Subarnarekha, on the north. The peaks are densely wooded to the summit, and, except at the regular passes, are inaccessible to beasts of burden. The intermediate valleys yield rich crops in return for negligent cultivation; and a vast quantity of land might be reclaimed on their outskirts and lower slopes."

Hence, during the interval between 4 P. M. of the 29th and 10 A. M. of the 30th, the centre of the storm had crossed the Balasore coast, been transferred across the very broken and elevated ground of the North Orissa Hills, and was at 10 A. M. of the 30th in the direct line of its advance previous to crossing the hills. What actions occurred during its passage across this hilly country are unknown, but it is certain that they produced no appreciable resultant effect on the line of motion of the vortex, and only a very moderate one on the depression at the centre. This was 29.3" at 10 A. M. of the 30th, as compared with 29.14" at 10 A. M. of the 29th. There can be little doubt that the effect of the irregular character of the country would be to break up and disintegrate the cyclonic or rotatory motion in the lower atmospheric strata, or to dimi-



nish as a whole the intensity and amount of the cyclonic motion, and, therefore, also of the depression at the centre, which roughly measures the intensity of the disturbance.

The observations taken at 4 P. M. in the neighbourhood of the centre are given in the following table :—

| Station.            | Barometer at 4 P. M. reduced to sea level. | Change since 4 P. M. previous day. | Wind.                |   | Cloud amount at 4 P. M. |
|---------------------|--|------------------------------------|----------------------|---|-------------------------|
|                     |  |                                    | Direction at 4 P. M. | Amount in miles per hour since 10 A. M. |                         |
| Saugor Island ..... | 29·508                                     | + ·371                             | S. E.                | 20·0                                    | 10                      |
| Burdwan .....       | ·516                                       | + ·172                             | S. E.                | 12·0                                    | 9                       |
| Hazaribagh .....    | ·446                                       | — ·001                             | E.                   | 22·9                                    | 10                      |
| Sutna.....          | ·533                                       | + ·013                             | E. N. E.             | 24·5                                    | 6                       |
| Jubbulpore .....    | ·538                                       | — ·033                             | N. W.                | 24·8                                    | 10                      |
| Sconi.....          | ·543                                       | — ·038                             | W. N. W.             | 24·4                                    | 5                       |
| Nagpur .....        | ·546                                       | + ·007                             | N. W.                | 12·2                                    | 10                      |
| Raipore .....       | ·415                                       | — ·084                             | W.                   | 60·0                                    | 10                      |
| Sambalpore .....    | ·215                                       | — ·122                             | S. W.                | 1·5                                     | 10                      |
| Cuttack.....        | ·395                                       | + ·029                             | W. N. W.             | 65·0                                    | 10                      |

In comparing these observations with the preceding 10 A. M. observations, it should be remembered that the fall of the barometer between 10 A. M. and 4 P. M., due to the diurnal oscillation, is ·11" during the months of June and July in the Central Provinces. Hence, making allowance for this, it will be seen that the barometric changes due to the storm were of the following character. Pressure had increased about ·08" at Cuttack and ·11" at Hazaribagh, and had fallen ·03" at Sambalpore. It had, consequently, risen during the previous six hours at all stations in the immediate neighbourhood of its centre, except Sambalpore, the nearest station. These facts appear to establish in this case that which I believe, from an examination of other similar cyclonic disturbances, to be a general result of the advance of a storm over a hilly country, *viz.*, that the storm tends to break up, the cyclonic motion becoming more irregular, and the barometric depression smaller in amount over the greater part, if not the whole, of the area of cyclonic circulation, but fre-

quently extending over a larger area. In other words, the cyclonic action becomes less intense and more diffuse, which is probably the first step in the disintegration of cyclonic disturbances. On the other hand, if, after its passage across hills, it receives increased energy and again intensifies, this is usually indicated by a contraction of the storm area, and by an increase of the depression near the centre.

The position of the centre at 4 P. M. was apparently almost identical with that in which it had been at 10 A. M., and was, so far as can be inferred from the observations, in Lat.  $21^{\circ} 50'$  N. and Long.  $83^{\circ} 30'$  E., or about 20 miles to the west of its position at 10 A. M.

The rainfall during the previous 24 hours in Orissa and Chutia Nagpur is given in the following table:—

| DIVISION.          | Districts.         | Average rainfall of district. | Highest rainfall in district. |
|--------------------|--------------------|-------------------------------|-------------------------------|
| Orissa .....       | Pooree .....       | 1·83                          | 3·88                          |
|                    | Cuttack.....       | 2·07                          | 3·21                          |
|                    | Balasore... ..     | 3·02                          | 5·64                          |
| Chhattisgarh ..... | Bilaspore .....    | 0·51                          | 2·54                          |
|                    | Sambalpore .....   | 1·17                          | 4·08                          |
|                    | Raipore .....      | 1·30                          | 2·03                          |
| Nagpur .....       | Wardha .....       | 1·82                          | 2·71                          |
|                    | Bhundara .....     | 2·71                          | 4·54                          |
|                    | Balaghat .....     | 0·03                          | 0·10                          |
|                    | Nagpur .....       | nil.                          | nil.                          |
| Jubbulpore .....   | Jubbulpore .....   | 0·54                          | 0·65                          |
|                    | Seoni .....        | 0·73                          | 2·09                          |
|                    | Mandla .....       | 0·26                          | 1·81                          |
|                    | Damoh .....        | 0·26                          | 0·90                          |
|                    | Saugor .....       | 0·03                          | 0·11                          |
| Nerbudda .....     | Narsinghpore ..... | 0·88                          | 3·00                          |
|                    | Chhindwara .....   | 1·03                          | 4·09                          |
|                    | Betul.....         | 0·43                          | 2·83                          |
|                    | Hoshangabad .....  | 0·01                          | 0·05                          |
|                    | Nimar .....        | nil.                          | nil.                          |

The meteorological information extracted from the logs of vessels at the Head of the Bay on the 30th is given to show the improvement in the weather, and the establishment of southerly winds over the Head of the Bay.

30th June 1883.

| Vessel.                 | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Wind.    |        | REMARKS.   |
|-------------------------|---------|-----------------|------------------|---------------------------------------|----------|--------|--|
|                         |         |                 |                  |                                       | Dir.     | Force. |  |
| Bancoora ..             | 4 A. M. |                 |                  | 29.552                                | S. W.    | 5      | Strong wind and over-<br>cast.   |
|                         | 8 A. M. |                 |                  | .539                                  | S. W.    | 3      | Moderate breeze and<br>fine throughout.  |
|                         | Noon    | 20° 01'         | 88° 25'          | .542                                  | S. W.    | 3      | Do. do. do.  |
|                         | 4 P. M. |                 |                  | .638                                  | S.       | 3      | Current 80 miles ad-<br>verse.   |
|                         | 8 P. M. |                 |                  | .539                                  | S.       | 3      | Moderate breeze and<br>fine.   |
|                         | Midnt.  |                 |                  | .552                                  | S.       | 3      | Moderate and fine at<br>Saugor.  |
| Star of Al-<br>bion ... | 4 A. M. |                 |                  | 29.540                                |          |        |  |
|                         | 8 A. M. |                 |                  | .570                                  |          |        |  |
|                         | Noon    | 20° 15'         | 87° 28'          | .610                                  | S. S. W. | 6 to 4 | Gale moderating, wea-<br>ther finer and less<br>sea.   |
|                         | 4 P. M. |                 |                  | .620                                  | S.       |        |  |
|                         | 8 P. M. |                 |                  | .670                                  |          |        |  |
|                         | Midnt.  |                 |                  | .670                                  |          |        | Latter part much finer.  |
| Saint Mag-<br>nus ..... | 4 A. M. |                 |                  | 29.440                                | S. S. W. | 8      | Squally rainy weather,<br>heavy sea.   |
|                         | 8 A. M. |                 |                  | .490                                  | S. S. W. | 7      | Do. do. do.  |
|                         | Noon    | 20° 32'         | 87° 56'          | .470                                  | S. S. W. | 6      | Strong breeze, cloudy<br>hazy weather.   |
|                         | 4 P. M. |                 |                  | .490                                  | S.       | 5      | Cloudy rainy weather,<br>nasty sea.  |
|                         | 8 P. M. |                 |                  | .570                                  | S.       | 4      | Moderate and fine.   |
| Scottish<br>Chieftain   | 4 A. M. |                 |                  | 29.450                                | S. W.    | 5      | Weather having a<br>much finer look, and<br>barometer rising, are<br>proofs that the strong<br>winds are now over. |
|                         | 8 A. M. | 20° 50'         |                  | .500                                  |          | 4      |  |
|                         | Noon    | 20° 32'         | 87° 34'          | .430                                  |          | 3      |  |
|                         | 4 P. M. |                 |                  | .580                                  |          | 1      | A very strong wester-<br>ly current.   |
|                         | 8 P. M. |                 |                  | .620                                  |          | 1      |  |
|                         | Midnt.  |                 |                  | .680                                  |          |        |  |
| Pemba ...               | 4 A. M. |                 |                  | 29.490                                | S. W.    | 6      | A. M. Strong breeze,<br>sea going down.  |
|                         | 8 A. M. |                 |                  | .540                                  | ...      | 6      |  |
|                         | Noon    | 20° 33'         | 88° 31'          | .540                                  | ...      | 5      | Noon. Moderate breeze<br>and clear.  |
|                         | 4 P. M. |                 |                  | .520                                  | ...      | 5      | 3.45 P. M. Passed E.<br>Channel Light Vessel,  |
|                         | 8 P. M. |                 |                  | .580                                  | ...      | 5      | 8 P. M. Anchored in<br>Saugor Roads.   |
|                         | Midnt.  |                 |                  | .600                                  | ...      | 5      |  |

| Vessel.             | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Wind.    |        | REMARKS.               |
|---------------------|---------|-----------------|------------------|---------------------------------------|----------|--------|------------------------|
|                     |         |                 |                  |                                       | Dir.     | Force. |                        |
| British<br>Princess | 4 .M.   |                 |                  |                                       |          | 9      | Squally with rain.     |
|                     | 8 A. M. |                 |                  |                                       |          | 9      | Sea very high.         |
|                     | Noon    | 20° 33'         | 88° 19'          |                                       |          | 8      | Sea very high.         |
|                     | 4 P. M. |                 |                  |                                       |          | 8      |                        |
|                     | 8 P. M. |                 |                  |                                       |          | 6      | Sea very high.         |
|                     | Midnt.  |                 |                  |                                       |          | 5      | High confused sea.     |
| Prince<br>Amadeo    | 4 A. M. |                 |                  |                                       | S. S. W. | 10     | Midnight. Gale break-  |
|                     | Noon    | 20° 39'         | 88° 20'          | 29.530                                | S.       | 8      | ing.                   |
|                     | 8 P. M. |                 |                  |                                       |          | 5      | 4 A. M. Strong S. S.   |
|                     | Midnt.  |                 |                  |                                       |          | 5      | W., occasional heavy   |
|                     |         |                 |                  |                                       |          |        | squalls.               |
| Commillah           |         |                 |                  |                                       |          |        | Noon. Strong wind S.,  |
|                     |         |                 |                  |                                       |          |        | weather finer.         |
|                     | 4 A. M. |                 |                  | 29.349                                | S. W.    | 9      | A. M. Hard squalls and |
|                     | 8 A. M. |                 |                  | .423                                  | S. S. W. | 8      | heavy rain and high    |
|                     | Noon    |                 |                  | .434                                  | S. S. W. | 7      | sea, stood to south-   |
|                     | 4 P. M. |                 |                  | .401                                  | S. W.    | 5      | ward. A very high      |
|                     | 8 P. M. |                 |                  | .464                                  | Var.     | 4      | sea running from       |
|                     | Midnt.  |                 |                  | .569                                  | E. S. E. | 3      | S. W. 5 A. M. Stood    |
|                     |         |                 |                  |                                       |          |        | up to Northward.       |
|                     |         |                 |                  |                                       |          |        | Weather clearing at    |
|                     |         |                 |                  |                                       |          |        | times for observa-     |
|                     |         |                 |                  |                                       |          |        | tions. 8 A. M. Hard    |
|                     |         |                 |                  |                                       |          |        | squalls from S. W.     |
|                     |         |                 |                  |                                       |          |        | and high sea. Noon.    |
|                     |         |                 |                  |                                       |          |        | Overcast, weather      |
|                     |         |                 |                  |                                       |          |        | hazy. 4 P. M. Fine     |
|                     |         |                 |                  |                                       |          |        | weather.               |

The preceding observations call for little remark. They show that south-westerly winds were fully established over the whole of the north of the Bay, but that they were diminishing rapidly in force. Before sunset, moderate breezes and finer weather had set in. Heavy squalls came up during the early part of the day, but the only vessel which reports rain during the afternoon was the *Saint Magnus*. In her case, however, it is stated that the weather improved rapidly and was fine, with moderate winds, at 8 P. M. Hence, the stormy weather in the Bay ceased about noon of the 30th. A heavy swell continued to run for some little time afterwards, and strong westerly winds prevailed for the next 24 hours.

*July 1st.*—The following table gives the observations taken at a few of the most important stations, and indicates the general character of the weather over India on the morning of the 1st :—



| STATION.        | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind.                  |   | Cloud amount at 10 A. M. | Rainfall at 10 A. M. preceding 24 hours. | Weather.         |
|-----------------|---|-------------------------------------|------------------------|---|--------------------------|--|------------------|
|                 |   |                                     | Direction.<br>10 A. M. | Amount in miles per hour since 10 A. M. previous day. |                          |  |                  |
| Calcutta.....   | 29.676                                      | + .121                              | S. E.                  | 7   | 8                        | 0.29                                     | Fine.            |
| Allahabad ..... | .566  | — .070                              | E. N. E.               | 8   | 10                       | ...                                      | Strong wind.     |
| Lahore .....    | .701  | + .212                              | N.                     | 3   | 8                        | 0.77                                     | Dark, gloomy.    |
| Kurrachee.....  | .642  | + .057                              | W. S. W.               | 17  | 9                        | 0.17                                     | Sultry.          |
| Bombay .....    | .765  | — .010                              | W.                     | 17  | 10                       | 0.21                                     | Showery.         |
| Jeypore .....   | .678  | + .032                              | N.                     | 5   | 7                        | 0.74                                     | Showery.         |
| Nagpur .....    | .471  | — .203                              | W.                     | 11  | 10                       | 4.08                                     | Continuous rain. |
| Madras .....    | .775  | — .038                              | W.                     | 8   | 6                        | ...                                      | Fine.            |
| Bangalore ..... | .803  | — .042                              | S. W.                  | 11  | 5                        | ...                                      | Fine.            |

The observations of the 1st indicate that the barometric depression moved during that day in the same direction as hitherto and at a rate of about 15 miles per hour. The westward motion of the depression had caused a fall of nearly two-tenths of an inch in the barometer over the greater part of the Central Provinces, and a general, although a slight, decrease over the whole of the Peninsula and Bombay. In Bengal, the rapid recovery in progress on the 30th continued. A rapid rise had also occurred over the Punjab and the western districts of the North Western Provinces, due to some other and independent action. A very distinct circulation of the air was shown round the centre of depression. In the mid-Gangetic valley, the winds had drawn round to north-east, and, over the western portions of the Central Provinces, they were blowing from north-west. Moderately strong winds continued at the Head of the Bay and in South Bengal. No change of importance had occurred in the wind directions over Bombay and the south of the Peninsula. Strong west winds prevailed along the Bombay coast, where, however, little or no rain was falling. Local winds obtained in the Punjab. The sky was less clouded, the weather finer, and rainfall less in amount over the Gangetic delta and valley. The depression was, however, giving very heavy rain to the Central Provinces, where the sky was overcast. Over the remainder of the country, the weather was of the usual monsoon character.

The storm had advanced through the Chhatisgarh division of the Central Provinces (which includes the Sambalpur, Bilaspore, and Raipore districts), and was now passing through the Jubbulpore and Nagpur divisions.

The following table gives the 10 A. M. observations at the stations in the neighbourhood of the centre at that hour:—

| STATION.       | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind.                 |   | Cloud amount at 10 A. M. | Rainfall at 10 A. M. of preceding 24 hours. | Weather.         |
|----------------|---|-------------------------------------|-----------------------|---|--------------------------|---|------------------|
|                |   |                                     | Direction at 10 A. M. | Amount in miles per hour since 10 A. M. previous day. |                          |   |                  |
| Sambalpur ...  | 29.526                                      | + .173                              | S. W.                 | 1.4   | 6                        | 1.84  |                  |
| Raipore .....  | .535  | + .024                              | S. W.                 | 20.0  | 10                       | ...   | Overcast.        |
| Hazaribagh ... | .627  | + .109                              | E. S. E.              | 20.0  | 8                        | 0.34  | Gale of wind.    |
| Sutna.....     | .534  | — .090                              | E.                    | 21.0  | 10                       | 0.08  | Ditto.           |
| Seoni.....     | .463  | — .202                              | N. N. W.              | 15.0  | 10                       | 4.60  | Continuous rain. |
| Jubbulpore ... | .483  | — .204                              | N. N. E.              | 8.0   | 10                       | 1.82  | Moist & muggy.   |
| Nagpur .....   | .471  | — .203                              | W.                    | 11.0  | 10                       | 4.08  |                  |

The number of observatories in Chutia Nagpore and the north-eastern districts of the Central Provinces is very small for their extent. Hence, it is not possible to state with approximate exactness the position of the centre of the depression at this time.

The observations, however, indicate that the centre was to the east of Seoni, and that it was at nearly equal distances from Jubbulpore, Seoni, and Nagpore, and hence almost certainly in Lat. 22° N. and Long. 81° E.

The following table gives the observations at 4 P. M. for the determination of the position of the centre at that hour :—

| STATION.         | Barometer at 4 P. M. reduced to sea level. | Change since 4 P. M. previous day. | Wind.                |   | Cloud amount at 4 P. M. | Weather.           |
|------------------|--|------------------------------------|----------------------|---|-------------------------|--------------------|
|                  |  |                                    | Direction at 4 P. M. | Amount in miles per hour since 10 A. M. |                         |                    |
| Nagpur .....     | 29.355                                     | — .191                             | W.                   | 11.7                                    | 10                      | Overcast.          |
| Raipore .....    | .415                                       | — 0                                | S. W.                | 64.1                                    | 10                      | Overcast.          |
| Seoni .....      | .323                                       | — .220                             | E.                   | 9.2                                     | 10                      | Overcast, raining. |
| Sutna.....       | .435                                       | — .098                             | E.                   | 30.0                                    | 7                       |                    |
| Jubbulpore ..... | .375                                       | — .163                             | E. N. E.             | 14.2                                    | 10                      | Gloomy.            |
| Saugor .....     | .412                                       | — .178                             | N. W.                | 2.3                                     | 8                       |                    |
| Hoshangabad ...  | .420                                       | — .153                             | W. S. W.             | 2.8                                     | 10                      | Overcast.          |
| Khandwa .....    | .478                                       | — .132                             | W. N. W.             | 20.1                                    | 10                      | Raining.           |
| Akola.....       | .509                                       | — .091                             | W. N. W.             | 21.0                                    | 10                      | Overcast.          |
| Indore .....     | .533                                       | — .073                             | W. N. W.             | 15.0                                    | 10                      | Overcast.          |

Allowing for the amount of the fall of the barometer between 10 A. M. and 4 P. M. due to the diurnal oscillation, the barometer had risen at Sambalpore '11", and had also risen at Akola '02". The only portion of the area in which it had fallen was that represented by the station of Seoni, where it had fallen '03".

The wind directions at Seoni and Nagpore were east and west respectively, and indicate that the centre was between these two stations, and probably some little distance to the east of the line joining them. Its probable position was hence in Lat. 22° N. and Long. 79° 45' E.

The following table gives the average rainfall during the previous 24 hours in every district of Orissa and the Central Provinces :—

| Division.         | District.          | Average<br>rainfall of<br>district. | Highest in<br>district. |
|-------------------|--------------------|-------------------------------------|-------------------------|
| Orissa .....      | Pooree .....       | 0.01                                | 0.05                    |
|                   | Cuttack .....      | nil.                                | nil.                    |
|                   | Balasore .....     | 0.09                                | 0.20                    |
| Chattisgarh ..... | Sambalpore .....   | 1.05                                | 5.25                    |
|                   | Raipore .....      | 1.60                                | 4.25                    |
|                   | Bilaspore .....    | 0.56                                | 2.92                    |
| Nagpore .....     | Bandhara .....     | 2.97                                | 4.36                    |
|                   | Balaghat .....     | 2.47                                | 5.00                    |
|                   | Nagpore .....      | 3.88                                | 4.80                    |
|                   | Wardha .....       | 1.91                                | 4.18                    |
| Jubbulpore .....  | Jubbulpore .....   | 0.66                                | 1.62                    |
|                   | Seoni .....        | 2.76                                | 5.65                    |
|                   | Mandla .....       | 0.02                                | 0.15                    |
|                   | Damoh .....        | 0.27                                | 0.80                    |
|                   | Saugor .....       | 0.28                                | 0.48                    |
| Nerbudda .....    | Nursinghpore ..... | 0.53                                | 1.25                    |
|                   | Chhindwara .....   | 4.16                                | 4.90                    |
|                   | Betul .....        | 3.91                                | 6.13                    |
|                   | Hoshangabad .....  | 2.90                                | 5.99                    |
|                   | Nimar .....        | 0.64                                | 1.01                    |

This table indicates that rain had practically ceased to fall in Orissa, and that moderate rain had fallen in Chattisgarh. Heavy rain had been received in all districts of the Central Provinces through which the cyclone passed during the day, namely, the Seoni, Chhindwara, and Hoshang-

abad districts, and also in the districts to the south of the line of motion; whilst in the districts to the north the rainfall was light.

The following table shews that the amount of rain in Bengal was very small:—

| Districts.              | Average rain-fall of district. | Highest in district. |
|-------------------------|--------------------------------|----------------------|
| Orissa .....            | 0.04                           | 0.20                 |
| South West Bengal ..... | 0.12                           | 0.96                 |
| East Bengal .....       | 0.09                           | 0.50                 |
| North Bengal .....      | 0.08                           | 1.37                 |
| North Behar .....       | nil.                           | 0.07                 |
| South Behar .....       | 0.05                           | 0.80                 |
| Chutia Nagpore .....    | 0.11                           | 0.46                 |

*2nd July.*—The following table gives the 10 A. M. observations of this day at the nine most important observatories in India.

| STATIONS.       | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind.      |   | Cloud amount at 10 A. M. | Rainfall at 10 A. M. of preceding 24 hours. | Weather.       |
|-----------------|---|-------------------------------------|------------|---|--------------------------|---|----------------|
|                 |   |                                     | Direction. | Amount in miles per hour since 10 A. M. previous day. |                          |   |                |
|                 |   |                                     | 10 h.      |   |                          |   |                |
| Calcutta.....   | 29.673                                      | — 003                               | S. W.      | 4   | 8                        | 0.03  | Fine.          |
| Allahabad ..... | .613  | + .047                              | E.         | 8   | 2                        | 0.04  | Strong wind.   |
| Lahore .....    | .590  | — .111                              | W.         | 2   | 5                        | ...   | Fine.          |
| Kurrachee.....  | .556  | — .086                              | N. W.      | 18  | 2                        | ...   | Fine.          |
| Bombay.....     | .708  | — .057                              | W. S. W.   | 20  | 10                       | 0.15  | Showery.       |
| Jeyapore .....  | .541  | — .137                              | E. S. E.   | 7   | 6                        | ...   | Fine.          |
| Nagpore.....    | .621  | + .150                              | S. W.      | 18  | 10                       | 3.22  | Strong wind.   |
| Madras .....    | .795  | + .020                              | W.         | 6   | 7                        | 1.83  | Thunder storm. |
| Bangalore ..... | .794  | — .009                              | W. S. W.   | 10  | 6                        | ...   | Fine.          |

The observations taken throughout India shew that the barometric depression had continued to travel westward in the same general direction as during the previous two days, and with the same velocity approximately as during the afternoon of the 1st. A rapid recovery of pressure had occurred over the greater part of the Central Provinces, amounting at several stations to .15'. The barometer had on the other hand fallen over the districts towards which the centre was advancing. The fall was greatest at Indore, where it slightly exceeded .25" since 10 A. M. of the 1st. Pressure had decreased over the whole of the Punjab, the North-Western Provinces, Bombay, and the greater part of Bengal and Burmah. This fall was due to general actions unconnected with the continuance of the depression in Western India.



The general character of the air motion remained the same, except in the neighbourhood of the moving area of depression. Southerly winds now prevailed in the Central Provinces. The westerly winds on the Bombay coast were slightly stronger than they had been on the previous day. The easterly winds prevalent over the area to the north and north-east of the storm centre were comparatively dry, and little or no rain fell in that part of the depression where they were blowing. The rainfall was heavy in the southern quadrant of the disturbance.

Little or no rain was falling at the time in Assam, North Bengal, Behar, the North-Western Provinces, the Punjab, and over the greater part of Bombay.

During the interval between 4 P. M. of the 1st and 10 A. M. of the 2nd, the centre continued to advance in a general westerly direction through the Narbadda Division of the Central Provinces.

The following are the observations taken at the meteorological stations in the area of depression at 10 A. M. of the 2nd.

| STATIONS.      | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind.                 |   | Cloud amount at 10 A. M. | Rainfall at 10 A. M. preceding 24 hours. | Weather          |
|----------------|---|-------------------------------------|-----------------------|---|--------------------------|--|------------------|
|                |   |                                     | Direction at 10 A. M. | Amount in miles per hour since 10 A. M. previous day. |                          |  |                  |
| Saugor .....   | 29.488                                      | — .056                              | N. E.                 | 11.0  | 8                        | 0.38                                     | Showery.         |
| Akola.....     | .577  | — .061                              | W.                    | 22.0  | 10                       | 7.43                                     | Continuous rain. |
| Amraoti.....   | .553  | — .050                              | W. S. W.              | 42.0  | 9                        | 6.35                                     | Ditto.           |
| Neemuch .....  | .509  | — .154                              | E. N. E.              | 20.0  | 10                       | 0.86                                     | Showery.         |
| Indore .....   | .410  | — .259                              | N. E.                 | 13.0  | 10                       | 1.58                                     | Showery.         |
| Jeypore .....  | .541  | — .137                              | E. S. E.              | 7.0   | 6                        | ...                                      | Fine.            |
| Ajmere .....   | .546  | — .140                              | N. E.                 | 5.0   | 4                        | 0.43                                     | Thunder.         |
| Khandwa .....  | .494  | — .141                              | W. S. W.              | 13.0  | 10                       | 2.64                                     | Continuous rain. |
| Mount Abu ...  | 25.692                                      | — .169                              | N.                    | 9.0   | 9                        | 3.34                                     | Ditto.           |
| Surat .....    | 29.588                                      | — .138                              | S. W.                 | 17.0  | 10                       | 0.33                                     | Showery.         |
| Malagaon ..... | .670  | — .073                              | W.                    | 18.0  | 10                       | 2.83                                     | Continuous rain. |
| Nagpore .....  | .621  | + .150                              | S. W.                 | 18.0  | 10                       | 3.22                                     | Strong wind.     |
| Seoni.....     | .603  | + .140                              | S.                    | 12.0  | 8                        | 1.20                                     | Continuous rain. |
| Jubbulpore ... | .599  | + .116                              | S.                    | 12.0  | 9                        | 0.05                                     | Strong wind.     |

The barometer was lowest at Indore. The barometric heights and wind directions, when charted, indicate that the centre of the depression was at noon very near Indore and to the east of it, and hence in Lat.  $22\frac{1}{2}^{\circ}$  N. and Long.  $76^{\circ}$  E. Strong winds and very heavy rain characterized the western and southern quadrants. In the northern quadrant, winds were much more moderate, and rain fell only near the centre of the depression.

The following are the 4 P. M. observations, which enable the position of the depression and its centre to be determined at that hour :—

| STATION.        | Barometer at 4 P. M. reduced to sea level. | Change since 4 P. M. previous day. | Wind.                |   | Cloud amount at 4 P. M. | Weather.     |
|-----------------|--|------------------------------------|----------------------|---|-------------------------|--------------|
|                 |  |                                    | Direction at 4 P. M. | Amount in miles per hour since 10 A. M. |                         |              |
| Saugor .....    | 29.473                                     | + .061                             | S.                   | 14.0                                    | 8                       | Cloudy.      |
| Akola.....      | .529                                       | + .020                             | W. S. W.             | 21.7                                    | 10                      | Strong wind. |
| Amraoti.....    | .565                                       | + .136                             | S. W.                | 23.3                                    | 10                      | Strong wind. |
| Neemuch .....   | .368                                       | — .148                             | E.                   | 11.7                                    | 9                       |              |
| Indore .....    | .414                                       | — .119                             | S. W.                | 8.7                                     | 10                      | Overcast.    |
| Jeypore .....   | .398                                       | — .125                             | E.                   | 10.9                                    | 7                       | Strong wind. |
| Ajmere .....    | .399                                       | — .183                             | E.                   | 12.4                                    | 5                       |              |
| Khandwa .....   | .444                                       | — .034                             | W.                   | 17.6                                    | 10                      |              |
| Surat .....     | .495                                       | — .135                             | W. S. W.             | 33.0                                    | 10                      | Overcast.    |
| Malegaon .....  | .557                                       | — .050                             | W.                   | 19.8                                    | 10                      | Strong wind. |
| Deesa.....      | .370                                       | — .166                             | W.                   | 18.0                                    | 10                      | Overcast.    |
| Rajkot .....    | .458                                       | — .131                             | W.                   | 20.3                                    | 10                      | Strong wind. |
| Bhuj .....      | .422                                       | — .151                             | W.                   | 15.8                                    | 8                       | Strong wind. |
| Hyderabad ..... | .422                                       | — .175                             | S. W.                | 5.0                                     | 9                       | Overcast.    |

Allowing for the amount of the diurnal oscillation between 10 A. M. and 4 P. M., it will be seen that the barometer had fallen during the preceding six hours at Neemuch, Ajmere, and Deesa, whilst it had risen rapidly in the Central Provinces. The centre was between Neemuch and Deesa, where the barometric heights were practically the same, and winds were in opposite directions. It was approximately in Lat.  $23^{\circ} 30'$  N. and Long.  $74^{\circ} 30'$  E.

The following table gives the rainfall in each district of the Central Provinces during the 24 hours preceding 6 P. M. of the 2nd.

| Division.         | District.          | Average Rainfall of district. | Highest in district. |
|-------------------|--------------------|-------------------------------|----------------------|
| Chattisgarh ..... | Sambalpoore .....  | 0·09                          | 0·45                 |
|                   | Raipore.....       | nil.                          | nil.                 |
|                   | Bilaspore .....    | 0·05                          | 0·20                 |
| Nagpur .....      | Bhandara .....     | 0·25                          | 0·70                 |
|                   | Balaghat .....     | 0·71                          | 1·90                 |
|                   | Nagpur .....       | 2·25                          | 3·86                 |
|                   | Wardha .....       | nil.                          | nil.                 |
| Jubbulpore.....   | Jubbulpore .....   | 0·02                          | 0·05                 |
|                   | Seoni.....         | 0·06                          | 0·17                 |
|                   | Mandla.....        | nil.                          | nil.                 |
|                   | Damoh .....        | 0·07                          | 0·20                 |
|                   | Saugor... ..       | 0·10                          | 0·41                 |
| Narbudda .....    | Narsinghpore ..... | 0·19                          | 0·75                 |
|                   | Chhindwara .....   | 0·06                          | 0·19                 |
|                   | Betul.....         | 0·91                          | 2·45                 |
|                   | Hoshangabad .....  | 0·96                          | 3·35                 |
|                   | Nimar .....        | 5·62                          | 8·20                 |

The rainfall of the previous 24 hours was small in amount. The Nagpur district received local heavy rainfall. The only district where the rainfall due to the cyclonic disturbance was large in amount was the Nimar district. It was in the southern quadrant of the storm area during the greater part of the day, and received an average of 5·62 inches.

3rd July.—The following table gives the observations for the 3rd July at the chief meteorological stations in India :—

| STATION.        | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind.      |   | Cloud amount at 10 A. M. | Rainfall at 10 A. M. of preceding 24 hours. | Weather.      |
|-----------------|---|-------------------------------------|------------|---|--------------------------|---|---------------|
|                 |   |                                     | Direction. | Amount in miles per hour since 10 A. M. previous day. |                          |   |               |
|                 |   |                                     | 10 h.      |   |                          |   |               |
| Calcutta .....  | 29·685                                      | + ·012                              | E. S. E.   | 3   | 9                        | nil.  | Fine.         |
| Allahabad ..... | ·712  | + ·099                              | N.         | 4   | 4                        | nil.  | Fine.         |
| Lahore .....    | ·613  | + ·023                              | E.         | 1   | 5                        | nil.  | Fine.         |
| Kurrachee.....  | ·446  | — ·110                              | N. N. W.   | 18  | 9                        | 0·05  | Gloomy.       |
| Bombay.....     | ·732  | + ·024                              | S. S. W.   | 25  | 10                       | 0·21  | Gale of wind. |
| Jeypore.....    | ·664  | + ·123                              | S. S. W.   | 12  | 8                        | nil.  | Strong wind.  |
| Nagpur .....    | ·760  | + ·139                              | S. S. W.   | 6   | 5                        | 0·04  | Showery.      |
| Madras .....    | ·845  | + ·050                              | S. W.      | 6   | 5                        | 0·11  | Showery.      |
| Bangalore ...   | ·854  | + ·060                              | S. W.      | 8   | 5                        | nil.  | Fine.         |

The depression was now in the immediate neighbourhood of the Arabian Sea, between Kurrachee and Rajkot. The barometer during the previous 24 hours had fallen between '1" and '15" in Sind, Cutch, Guzerat, and the adjacent districts of Rajputana. In the rear of the disturbance, over the Central Provinces, the Berars, and Central India, a recovery of pressure, varying in amount between '15" and '25", had occurred. Over the remainder of India, pressure had increased briskly. The depression in Cutch and Guzerat had consequently been emphasized by these changes, and the baric gradients over the area of depression were large. South-westerly gales were now blowing on the west coast, from Bombay northwards, and were giving very heavy rain over the southern and eastern portions of the depression. Over Northern India, the winds varied considerably in direction and were light and unsteady. The weather was cloudy, and light and partial rain was falling, over the greater part of Northern India, except the Punjab and parts of the North-Western Provinces.

The centre of the depression at 4 P. M. on the 2nd was to the west of Neemuch in the Indore State, and was advancing westwards into Guzerat. The following table gives the 10 A. M. observations of the 3rd at the stations in the area of cyclonic disturbance:—

| STATIONS.      | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind.                 |   | Cloud amount at 10 A. M. | Rain at 10 A. M. preceding 24 hours. | Weather.                           |
|----------------|---|-------------------------------------|-----------------------|---|--------------------------|--------------------------------------|------------------------------------|
|                |   |                                     | Direction at 10 A. M. | Amount in miles per hour since 10 A. M. previous day. |                          |                                      |                                    |
| Kurrachee..... | 29.446                                      | — .110                              | N. N. W.              | 18.0  | 9                        | 0.05                                 | Gloomy.                            |
| Rajkote .....  | 29.435                                      | — .171                              | S. W.                 | 33.0  | 10                       | 9.85                                 | Dust storm with rain.              |
| Deesa.....     | 29.467                                      | — .076                              | S. E.                 | 17.0  | 10                       | 0.43                                 | Threatening weather.               |
| Ajmere .....   | 29.636                                      | + .090                              | S. E.                 | 11.0  | 9                        | 0.10                                 | Strong wind.                       |
| Indore .....   | 29.676                                      | + .266                              | S. E.                 | 7.0   | 6                        | 0.10                                 | Gloomy.                            |
| Neemuch .....  | 29.639                                      | + .130                              | S. S. W.              | 22.0  | 10                       | 0.21                                 | Thunder and lightning at distance. |
| Bhuj .....     | 29.326                                      | — .207                              | N. N. W.              | 3.0   | 10                       | 0.76                                 | Fine.                              |
| Hyderabad ...  | 29.420                                      | — .137                              | N.                    | 5.0   | 8                        | 0.26                                 | Strong wind.                       |

The barometer had risen rapidly at Indore and Neemuch, whilst it had fallen somewhat less rapidly at Bhuj, Rajkote, Deesa, Hyderabad, and Kurrachee. The preceding observations indicate that the centre



was between the three stations of Bhuj, Rajkote, and Deesa, and probably not far from the first-named station, in Lat.  $23\frac{1}{2}^{\circ}$  N. and Long.  $69\frac{3}{4}^{\circ}$  E., and hence nearly in the centre of the district of Cutch. The observations show that winds were unusually light in the north-western quadrant. The average wind velocity at Bhuj during the previous 24 hours was only 3 miles, and at Hyderabad 5 miles. The westerly and south-westerly winds at Rajkote and other stations in the easterly and southerly quadrants contrast strikingly with the feeble winds to the north of the centre of the depression.

The following are the 4 P. M. observations taken at the stations within the storm area:—

| STATIONS.      | Barometer at 4 P. M. reduced to sea level. | Change since 4 P. M. previous day. | Wind.                |   | Cloud amount at 4 P. M. | Weather.      |
|----------------|--|------------------------------------|----------------------|---|-------------------------|---------------|
|                |  |                                    | Direction at 4 P. M. | Amount in miles per hour since 10 A. M. |                         |               |
| Kurrachee..... | 29·304                                     | —·182                              | N. N. W.             | 16·8                                    | 10                      | Strong wind.  |
| Rajkote.....   | 29·454                                     | —·004                              | S. S. W.             | 32·3                                    | 10                      | Strong wind.  |
| Mount Abu ...  | 25·598                                     | +·042                              | S.                   | 13·8                                    | 10                      | Gloomy.       |
| Ajmere .....   | 29·565                                     | +·166                              | W.                   | 12·2                                    | 5                       | Gloomy.       |
| Indore .....   | 29·627                                     | +·213                              | S.                   | 6·7                                     | 10                      | Gloomy.       |
| Neemuch .....  | 29·587                                     | +·219                              | S. S. W.             | 11·2                                    | 10                      | Gloomy.       |
| Bhuj .....     | 29·215                                     | —·207                              | S.                   | 25·7                                    | 10                      | Thunderstorm. |
| Hyderabad ...  | 29·317                                     | —·105                              | E. N. E.             | 58·8                                    | 6                       | Strong wind.  |
| Jacobabad..... | 29·382                                     | —·066                              | E.                   | 17·2                                    | 6                       | Strong wind.  |
| Multan .....   | 29·481                                     | +·021                              | N. E.                | 3·0                                     | 4                       | Fine.         |

When the observations are charted, they indicate that the centre was between Bhuj and Kurrachee, where the barometric readings were lowest, and winds were from S. and N. N. W.; and at a short distance to the W. N. W. of the former station. Its probable position was in Lat.  $23\frac{3}{4}^{\circ}$  N. and Long.  $68\frac{3}{4}^{\circ}$  E. If allowance be made for the diurnal oscillation, it will be seen that the barometer had altered little at Bhuj, and was rising quickly at Rajkote, but continued to fall rather rapidly at Kurrachee.

The following table gives the average rainfall in the divisions of Bengal:—

|                         | Average rainfall<br>in previous 24<br>hours. | Highest rainfall<br>in 24 hours. |
|-------------------------|--|----------------------------------|
| Orissa.....             | 0·03   | 0·30                             |
| South West Bengal ..... | 0·04   | 0·52                             |
| East Bengal .....       | 0·12   | 1·40                             |
| North Bengal .....      | 0·04   | 0·56                             |
| North Behar .....       | nil.   | nil.                             |
| South Behar .....       | 0·03   | 0·40                             |
| Chutia Nagpur .....     | 0·06   | 0·50                             |

The above return shews that, with the exception of a few local showers, rain had ceased in the Province of Bengal.

As daily returns of rainfall in Central India and the Bombay Presidency are not at my disposal, it is not possible to give full details of this element of observation for the previous 24 hours. The returns of Bhuj, Rajkote, Kurrachee, &c., however, indicate clearly that the rainfall was heavy over the southern half of the cyclonic area and light over the northern.

*4th July.*—The following are observations taken at 10 A. M. of the 4th, and illustrate the more important changes that had occurred during the previous 24 hours in the meteorology of India.

| STATIONS.     | Barometer at 10<br>A. M. reduced to<br>sea level. | Change since 10<br>A. M. previous<br>day. | Wind.                 |   | Cloud amount at 10<br>A. M. | Rainfall at 10 A. M.<br>preceding 24 hours. | Weather.             |
|---------------|---|---|-----------------------|---|-----------------------------|---|----------------------|
|               |   |   | Direction at<br>10 h. | Amount<br>in miles<br>per hour<br>since<br>10 A. M.<br>previous<br>day. |                             |   |                      |
| Calcutta ...  | 29·643  | —·042                                     | N. W.                 | 5   | 10                          | 2·12  | Gloomy.              |
| Allahabad...  | 29·669  | —·043                                     | N. W.                 | 2   | 5                           | ...   | Fine.                |
| Lahore .....  | 29·652  | +·039                                     | Calm.                 | 5   | 6                           | 0·89  | Fine.                |
| Kurrachee...  | 29·380  | —·066                                     | E.                    | 33  | 10                          | 0·83  | Duststorm with rain. |
| Bombay.....   | 29·867  | +·135                                     | S.                    | 28  | 10                          | 0·23  | Gale of wind.        |
| Jeypore ..... | 29·751  | +·087                                     | W. N. W.              | 7   | 8                           | ...   | Fine.                |
| Nagpore.....  | 29·811  | +·051                                     | W.                    | 4   | 7                           | ...   | Fine.                |
| Madras .....  | 29·864  | +·019                                     | W. S. W.              | 7   | 4                           | ...   | Fine.                |
| Bangalore ... | 29·901  | +·047                                     | W.                    | 7   | 4                           | ...   | Fine.                |

The observations taken at the observing stations in Sind and Guzerat at 10 A. M. are given below. They shew that the whirl was still quite distinctly marked, that it continued to advance to the westward, and that it was now near the Head of the Arabian Sea, to the S. W. of Kurrachee. A rapid rise of the barometer had occurred over upper Sind and Guzerat. Kurrachee was the only station where pressure was lower than on the morning of the 3rd. South-westerly winds prevailed in Cutch and Guzerat. The wind had shifted round to east at Kurrachee, and was blowing with considerable force. It brought up a dust-storm from the Rajputana desert followed by rain.

The centre of the depression had crossed the Sind coast during the previous evening. It is not possible to follow its motion further, as no observations are available for this portion of its path. It is, however, probable that it speedily broke up.

The following 10 A. M. observations taken at stations in Western India nearest the area of cyclonic disturbance illustrate the previous remarks.

| STATION.      | Barometer 10 A. M.<br>reduced to sea<br>level. | Change since 10<br>A. M. previous day. | Wind.                    |   | Cloud amount at 10<br>A. M. | Rainfall at 10 A. M.<br>preceding 24 hours. | Weather.                                  |
|---------------|--|--|--------------------------|---|-----------------------------|---|---|
|               |  |  | Direction at<br>10 A. M. | Amount in<br>miles per<br>hour since<br>10 A. M. pre-<br>vious day. |                             |   |   |
| Kurrachee...  | 29.380   | — .066                                 | E.                       | 33.0  | 10                          | 0.83  | Duststorm with<br>rain.                   |
| Mount Abu     | 25.890   | + .221                                 | S. S. W.                 | 17.0  | 10                          | 2.36  | Passing showers.                          |
| Deesa.....    | 29.725   | + .258                                 | S.                       | ?   | 10                          | 0.39  | Strong wind.                              |
| Rajkote ..... | 29.695   | + .260                                 | S. S. W.                 | 24.0  | 10                          | 0.58  | Clouds low, moving<br>rapidly with scuds. |
| Bhuj .....    | 29.583   | + .257                                 | S. S. W.                 | 11.0  | 10                          | 4.24  | Continuous rain.                          |
| Hyderabad .   | 29.626   | + .206                                 | S. W.                    | 240   | 10                          | 0.05  | Gale of wind.                             |
| Jacobabad...  | 29.614   | + .132                                 | E.                       | 90  | 3                           | ...   | Fine weather with<br>passing clouds.      |
| Mooltan.....  | 29.648   | + .073                                 | S. W.                    | 30  | 0                           | ...   | Fine weather with<br>passing clouds.      |

The following 4 P. M. observations shew that the barometer was rising rapidly at Kurrachee, as well as at the neighbouring stations, and that the wind at that station was slowly shifting round to its normal direction (S. W.) in July. They indicate clearly the continued existence of the whirl at the head of the Arabian Sea.

| STATIONS.      | Barometer at 4 P. M.<br>reduced to sea level. | Change since 4 P. M.<br>previous day. | Wind.                   |  | Cloud amount at<br>4 P. M. | Weather.     |
|----------------|---|---------------------------------------|-------------------------|--|----------------------------|--------------|
|                |   |                                       | Direction at<br>4 P. M. | Amount in<br>miles per<br>hour since<br>10 A. M. |                            |              |
| Kurrachee..... | 29.490  | + .186                                | E. S. E.                | 38.7   | 10                         | Strong wind. |
| Mount Abu ...  | 25.856  | + .258                                | S. S. W.                | 18.5   | 10                         | Gloomy.      |
| Deesa.....     | 29.667  | + .163                                | E. N. E.                | ?  | 10                         | Strong wind. |
| Rajkote .....  | 29.653  | + .199                                | S. W.                   | 28.7   | 8                          | Strong wind. |
| Bhuj .....     | 29.581  | + .366                                | S. S. W.                | 23.0   | 10                         | Strong wind. |

The history of the cyclone ends with the evening of the 4th, as the observations of the 5th and subsequent days shew that normal winds were established in Sind, and no further evidence of the existence of the cyclonic whirl is furnished by the land observations.

### CHAPTER III.

#### DISCUSSION OF THE MORE IMPORTANT FEATURES OF THE STORM OF THE 26TH JUNE TO THE 4TH JULY, 1883.

The cyclonic storm of the last week of June and the first week of July is interesting in several respects. It occurred after the rains had fully set in over Bengal, and was of unusual intensity in the Bay for a storm of the rains. After it passed into the Central Provinces, it acquired fresh energy, and advanced slowly across the Head of the Peninsula into Guzerat. During this part of its motion, it gave excessive rain, and presented in a marked degree the phenomena of a south-west monsoon storm on land. It was thus one of the most complete storms of the rains that has occurred in recent years, and as such is deserving of careful study. Before discussing its more important features in detail, it appears desirable to give a brief connected history of the antecedents, the formation, the progress, and the dissolution of the storm.

The south-west monsoon proper of 1883 commenced a few days earlier than usual at the Head of the Bay and in Bengal. The Bombay branch of the monsoon current was first felt in force on the Bombay coast on the 24th and 25th of June, when strong winds, almost approaching to a gale, were blowing, and general rain began and extended to the Central Provinces. Very shortly after the commencement of the south-west



monsoon proper in Bengal, an atmospheric eddy, or cyclonic vortex, formed in the north-west angle of the Bay. It passed through North Orissa, Chutia Nagpore, and South Behar into North Behar, where it broke up on the 20th of June. This disturbance drew large supplies of vapour from the southerly current advancing into Bengal from the Bay, which it discharged as rain in unusually large amounts over a considerable portion of Central and North Behar, and thus occasioned very heavy floods in the Gya, Behar, Patna, Durbhanga, and Mozufferpore districts.

The disappearance of this eddy or whirl was followed by a partial break in the rains. The winds, although they continued to blow from the normal directions over Bengal and in the south and centre of the Bay, fell off in strength. The sky was less densely clouded, more especially in Central Bengal and Behar. The air also was drier, and the rainfall much smaller in amount and confined to local showers, which fell chiefly in the neighbourhood of the hills in North and East Bengal. Whilst this partial break in the rains (which commenced on the 20th) held in Bengal, the winds diminished in strength *pari passu* over the north of the Bay. They were light to moderate, and rarely exceeded force 3. The weather was comparatively fine, and the sea almost smooth.

The wind observations taken at Nancowry and Port Blair show that the south-westerly winds of the centre and south of the Bay, which had been very feeble from the 15th, began to increase in force on the 23rd, and blew strongly during the remainder of the month. This apparently indicated the commencement of another burst of the monsoon.

It appears to be a general rule that each strong advance of south-west monsoon winds and consequent influx of aqueous vapour into Bengal commences in the south of the Bay. The winds first strengthen for some days in that part of the Bay, as is proved by the wind observations at the Ceylon stations and at Nancowry in the Nicobars. The area of strong winds then extends northwards. When the advancing strong winds approach the Burmah and Bengal coasts, there is a strong tendency to eddying motion at and near the front. This incipient vorticoise motion may, under favourable conditions, develop into a large cyclonic circulation and storm.

The strong current, in the present instance, advanced northwards along the Burmese and Arrakan coasts, and increased the strength of the winds at Diamond Island from the 25th, and at Akyab from the 26th. These may, therefore, be assumed as the dates of the arrival of the front of the advancing mass of air in the latitudes of these two stations. The log of the Pemba proves that, on the 27th, the force of the winds off the west Burmese coast was very considerable and averaged 9. At the same time that these strong winds were blowing off the Burmese coast, the winds at the Head of the Bay

were very light and variable, and of average force not exceeding 2. The strong advancing south-westerly current was opposed by the line of the Arrakan hills, by the resistances due to friction between itself and the earth's surface, and by the slower moving air currents to the west. The actual effect of the various resistances was to produce a deflection of the current to the west in the neighbourhood of the Burmese and Arrakan coasts, and a large amount of eddying or rotatory motion in the front of the current, and, therefore, also of ascensional motion and its concomitant action (in the case of a very humid current), rainfall. The energy or latent heat given out in the process of condensation, or rain formation, in its turn increased the ascensional motion, and the various actions and reactions gave rise to an extensive whirl near the Head of the Bay. The existence of this was plainly indicated on the morning of the 27th, when winds shifted round to north-east over the north-west of the Bay. Very heavy rain ("torrents of rain") were then falling over a comparatively small area near the Head of the Bay, which became an area of increasing barometric depression and of cyclonic air motion. The disturbance increased in intensity on the 28th and moved slowly westwards near the parallel of  $21^{\circ}$  N. At 10 A. M. of the 29th, the centre of the depression was between the Light Vessels at the Intermediate and Upper Gaspar stations. It was then travelling with an average velocity of about 3 miles an hour. Its rate of motion apparently increased as it approached the Balasore coast.

The storm advanced in a general W. N. W. direction during the afternoon of the 29th, and crossed the Balasore coast a few miles to the north of the station of Balasore a little before midnight. It then apparently marched without change of direction across the North Orissa hills, as, next morning at 10 A. M., the centre of the barometric depression was near to Sambalpore and in the continuation of its line of its advance on the 29th. The disturbance apparently diminished for some time, but began to draw supplies of vapour from the Bombay branch of the monsoon current, which had been blowing strongly for some days previous. In consequence of the increased energy thus given to it, it again intensified slightly and moved almost due westward across the Head of the Peninsula at an average rate of about fifteen miles per hour. On the morning of the 1st, the centre was near Seoni, on the morning of the 2nd near Indore, and on the morning of the 3rd near Bhuj, whence it passed westwards across the coast into the Arabian Sea, and was a little to the south of Kurrachee on the evening of the 3rd. The wind directions at Kurrachee and the neighbouring stations indicated cyclonic indraught to a centre, to the south-west of Kurrachee on the morning of the 4th, after which they give no further indications of

its existence. In the absence of observations, it is impossible to state whether it broke up immediately, or passed over the whole breadth of the Arabian Sea.

The following table gives the positions of the centre at the hours stated, from the 27th of June to the date of its disappearance beyond the limits of India in the Arabian Sea:—

| Date.            | Hour.                        | Position of centre.           |                               | Distance travelled during preceding interval. | Rate of motion. |
|------------------|------------------------------|-------------------------------|-------------------------------|---|-----------------|
|                  |                              | Latitude.<br>N.               | Longitude.<br>E.              |   |                 |
| June 27th ... {  | Noon.<br>4 P. M.             | 20° 30'<br>20° 35'            | 89° 45'<br>89° 35'            | 12  | 3               |
| June 28th ... {  | 10 A. M.<br>Noon.<br>4 P. M. | 21° 0'<br>21° 3'<br>21° 10'   | 88° 45'<br>88° 40'<br>88° 30' | 62<br>6½<br>13                                | 3½<br>3¼<br>3¼  |
| June 29th ... {  | 10 A. M.<br>Noon.<br>4 P. M. | 21° 30'<br>21° 30'<br>21° 35' | 87° 55'<br>87° 50'<br>87° 30' | 45<br>5½<br>22                                | 2½<br>2¾<br>5½  |
| June 30th ... {  | 10 A. M.<br>4 P. M.          | 22° 0'<br>22° 0'              | 84° 0'<br>83° 30'             | 230<br>32                                     | 13<br>5⅓        |
| July 1st ..... { | 10 A. M.<br>4 P. M.          | 22° 0'<br>22° 0'              | 81° 0'<br>79° 45'             | 162<br>80                                     | 9<br>13⅓        |
| July 2nd ..... { | 10 A. M.<br>4 P. M.          | 22° 30'<br>23° 30'            | 76° 0'<br>74° 30'             | 245<br>120                                    | 13½<br>20       |
| July 3rd ..... { | 10 A. M.<br>4 P. M.          | 23° 30'<br>23° 45'            | 69° 45'<br>68° 45'            | 308<br>66                                     | 17<br>11        |

The atmospheric whirl was fully developed on the 27th and continued intact for at least seven days. During the latter part of its existence, it drifted across from the coast of Orissa to the coast of Cutch or Sind, and disappeared and probably broke up in the Arabian Sea.

The following table gives the lowest reading of the barometer at 10 A. M., the average barometric height at the same station, and the amount of the greatest known barometric depression at 10 A. M. on each day:—



|              |                       | Lowest<br>10 A. M.<br>barometric<br>reading. | Average<br>10 A. M.<br>barometric<br>height.<br>July 1st. | Depression. |
|--------------|-----------------------|--|---|-------------|
| June 29th..  | Bay (Sandheads) ..... | 29·140                                       | 29·602  | ·462        |
| June 30th..  | Sambalpore .....      | 29·353                                       | 29·589  | ·236        |
| July 1st ... | Seoni.....            | 29·463                                       | 29·624  | ·161        |
| July 2nd...  | Indore .....          | 29·410                                       | 29·662  | ·252        |
| July 3rd ... | Bhuj .....            | 29·326                                       | 29·616  | ·290        |
| July 4th ... | Kurrachee .....       | 29·380                                       | 29·589  | ·209        |

Hence the barometric depression at the Head of the Bay was very nearly half an inch. During its progress overland, the depression observed nowhere exceeded '29", and, as two of the stations named in the preceding table (Indore and Bhuj) were at a very short distance from the centre, it is almost certain that the barometric depression on land, after crossing the Orissa hills, never exceeded three-tenths of an inch. The decrease in the amount of the depression was evidently due to the greater frictional resistance encountered by the cyclonic disturbance on land than at sea.

An interesting feature of the storm was that its centre moved in a path which was approximately straight. The general direction of its path was N. 83° W. or almost due west.

The steady march in an almost constant direction across the Continent is very striking, when the varying character of the surface over which it passed is taken into consideration. During the first part of its existence, it passed slowly over the water surface at the Head of the Bay, where the resistance to its motion was a minimum. After crossing the Balasore coast, it advanced intact over the North Orissa hills, a very broken and irregular country, the highest points of which are from 3000 to 4000 ft. high. It then crossed the highlands of Sambalpore (where the hills which rise out from the plateau attain an elevation varying from 1,500 to 2,500 feet) and passed over the comparatively low plain of Chattisgarh, the average height of which is less than 1000 feet. Thence it advanced through the Balaghat, Seoni, Chhindwara, and Betul districts of the Central Provinces, which cover the extensive highlands known as



the Satpura plateau, and have an average height of 2000 feet. It thence passed across the valleys of the Taptee and Nerbudda and the Vindhya Hills into Indore and Malwa. The average elevation of the Vindhya in that portion over which the cyclonic storm advanced is 2,500 feet. From Malwa, it passed westwards over the low plains of Guzerat and Cutch, the highest points of which do not exceed 800 or 900 feet in height, and crossed the coast of Sind between Bhuj and Kurrachee into the Arabian Sea, where its existence for at least twelve to eighteen hours afterwards is proved by the direction of the winds at Kurrachee and the neighbouring stations.

The above briefly indicates the varied character of the surface over which it advanced. During a considerable portion of its course on land, the average elevation of the country over which it travelled exceeded 2000 feet. Much of the ground was very broken and irregular country, the higher points of which exceeded 3000 feet in elevation. The only inference that can reasonably be drawn is that the cyclonic circulation extended to a height very considerably greater than 2000 or 3000 feet. Hence it was a cyclone of high elevation, and the cyclonic circulation near the earth's surface was of comparatively little importance, and not necessarily an index or measure of the intensity of the cyclone.

The chief features of the motion of the storm centre have already been indicated in the history of the cyclone. Its very slow motion during and for some time after its formation, or from noon of the 27th to noon of the 29th, is remarkable. During this interval of 48 hours, its rate of motion apparently never exceeded 5 miles per hour, and during the greater part of the period it varied between 2 and 4 miles. After noon of the 29th, it rapidly increased its speed, and, during the greater part of the next 24 hours, moved with a velocity varying between 10 and 15 miles. When the centre approached the high hills and broken ground of North Orissa, it experienced a very considerable retardation. As already stated (*vide* page 99), it lost energy and shewed signs of disintegration. The rainfall decreased in amount, the barometric depression was much smaller, and the disturbance was diffused over a larger area, although it was less regular and weaker in character. This was, however, followed by an increase of its energy due to its drawing supplies of vapour from the Bombay coast. The preceding changes were reversed. During this interval, the average rate of its motion was about 8 miles per hour. Its velocity increased on the 1st of July, and, during the remaining three days of its existence on land, it moved with a fairly uniform velocity of about 15 miles per hour.

Another important feature was the amount and distribution of the rainfall during the cyclonic storm. At the Head of the Bay, the rainfall

was torrential in character, more especially in the eastern and southern quadrants. The British Princess had "torrents of rain," the Saint Magnus "heavy continuous rain," the Star of Albion "thick continued rain," the Commillah "very heavy rain," and the Scottish Chieftain "heavy rain."

The following table gives the daily rainfalls during the period—June 28th to July 4th—at the meteorological stations situated in the area covered by the cyclonic storm during its existence on land:—

| Stations.           | June 1883. |       |       | July 1883. |      |       |      |
|---------------------|------------|-------|-------|------------|------|-------|------|
|                     | 28th.      | 29th. | 30th. | 1st.       | 2nd. | 3rd.  | 4th. |
| Pooree .....        | 0·59       | 9·44  | 2·25  | ...        | ...  | ...   | 0·23 |
| Saugor Island ..... | ...        | 0·17  | 0·36  | ...        | ...  | 1·08  | 3·82 |
| Balasore .....      | 0·94       | 2·65  | 5·64  | 0·17       | 0·21 | 0·12  | 0·76 |
| False Point .....   | 8·04       | 5·39  | 1·10  | 0·05       | ...  | ...   | 0·09 |
| Cuttack .....       | 1·79       | 5·61  | 3·21  | ...        | ...  | ...   | ...  |
| Sambalpur .....     | 0·05       | 2·47  | 7·00  | 1·84       | ...  | ...   | 0·80 |
| Raipore .....       | ...        | 0·11  | 2·03  | 2·16       | ...  | 0·03  | ...  |
| Nagpur .....        | 0·17       | ...   | ...   | 6·22       | 1·12 | ...   | ...  |
| Seoni .....         | 1·22       | 0·45  | ...   | 5·65       | 0·17 | ...   | ...  |
| Jubbulpore .....    | 0·12       | 0·12  | 0·65  | 1·62       | 0·05 | 0·06  | ...  |
| Pachmarhi .....     | 1·29       | ...   | 0·02  | 5·99       | 1·36 | ...   | 0·05 |
| Amraoti .....       | 0·85       | ...   | ...   | 4·60       | 3·65 | ...   | ...  |
| Akola .....         | 0·42       | ...   | ...   | 2·17       | 6·85 | 0·03  | ...  |
| Indore .....        | 0·07       | ...   | ...   | 1·01       | 0·89 | 0·02  | ...  |
| Neemuch .....       | 0·04       | ...   | 1·47  | 0·86       | 0·21 | 0·09  | ...  |
| Surat .....         | 3·64       | 3·51  | 0·52  | 0·11       | 1·78 | 3·76  | 0·35 |
| Ahmedabad .....     | 0·18       | 0·05  | ...   | ...        | 0·76 | 3·88  | 0·79 |
| Rajkote .....       | ...        | 0·46  | ...   | 0·13       | ...  | 10·05 | 0·40 |
| Bhuj .....          | 0·90       | 0·54  | 0·02  | ...        | 0·48 | 3·78  | 1·56 |
| Hyderabad .....     | 0·42       | ...   | ...   | ...        | ...  | 0·26  | 0·12 |
| Kurrachee .....     | ...        | 0·37  | ...   | 0·17       | 0·06 | 0·12  | 1·65 |
| Deesa .....         | 1·23       | 0·08  | 0·03  | ...        | 1·84 | 0·03  | 0·74 |
| Mount Abu .....     | 0·45       | 0·18  | 0·14  | 2·16       | 2·64 | 1·31  | 2·22 |
| Ajmere .....        | 0·07       | ...   | ...   | ...        | 0·43 | 0·10  | ...  |

As the rainfall was especially heavy in Orissa and the Central Provinces, I give the following table shewing the average district rainfall for each day of the period (June 27th to July 3rd) in these two divisions of the Empire, and illustrating more fully than the previous statement the distribution of the rainfall in a portion of the area covered by the disturbance. As daily returns of rainfall in Central India and the Bombay Presidency are not at my disposal, I am not able to give the corresponding data for the western portion of the course of the cyclone.

| Division.        | District.        | No. of Stations. | 27th. | 28th. | 29th. | 30th. | 1st. | 2nd. | 3rd. | Total. |
|------------------|------------------|------------------|-------|-------|-------|-------|------|------|------|--------|
| Orissa .....     | Pooree .....     | 5                | 0·23  | 2·58  | 6·15  | 1·83  | 0·01 | nil. | 0·06 | 10·86  |
|                  | Cuttack .....    | 5                | 0·06  | 3·03  | 4·50  | 2·07  | nil. | nil. | nil. | 9·66   |
|                  | Balasore .....   | 6                | 0·71  | 2·00  | 2·66  | 3·02  | 0·09 | 0·09 | 0·13 | 8·70   |
| Chittasgarh ...  | Sambalpure ...   | 5                | 0·32  | 0·31  | 0·74  | 1·17  | 1·05 | 0·09 | 0·01 | 3·69   |
|                  | Raipore .....    | 4                | 1·74  | nil   | 0·73  | 1·30  | 1·60 | nil. | 0·01 | 5·38   |
|                  | Bilaspore .....  | 7                | 0·11  | 0·51  | 0·35  | 0·51  | 0·56 | 0·05 | 0·01 | 2·05   |
| Nagpore .....    | Nagpur .....     | 5                | 1·06  | 1·48  | 0·19  | nil.  | 3·88 | 2·25 | 0·01 | 8·87   |
|                  | Bhandara .....   | 3                | 2·81  | 0·57  | 0·04  | 2·71  | 2·99 | 0·25 | 0·05 | 9·42   |
|                  | Wardha .....     | 4                | 1·29  | 0·01  | nil.  | 1·82  | 1·91 | nil. | 0·01 | 5·04   |
|                  | Balaghat .....   | 4                | 1·21  | 0·08  | 0·23  | 0·03  | 2·47 | 0·71 | 0·06 | 4·79   |
| Jubbulpore ..... | Jubbulpore ..... | 3                | 0·59  | 0·13  | 1·44  | 0·54  | 0·66 | 0·02 | 0·02 | 3·40   |
|                  | Sangor .....     | 4                | 0·46  | 0·26  | nil.  | 0·03  | 0·28 | 0·10 | nil. | 1·13   |
|                  | Damoh .....      | 5                | 0·41  | 0·04  | nil.  | 0·26  | 0·27 | 0·07 | nil. | 1·05   |
|                  | Seoni .....      | 3                | 0·83  | 0·68  | 0·38  | 0·73  | 2·76 | 0·06 | 0·03 | 5·47   |
|                  | Mandla .....     | 7                | 0·02  | 0·20  | 0·04  | 0·26  | 0·02 | nil. | nil. | 0·54   |
| Nerbudda .....   | Betul .....      | 7                | 0·55  | 0·19  | 0·12  | 0·43  | 3·91 | 0·91 | 0·04 | 6·15   |
|                  | Chhindwara ..... | 3                | 1·15  | 0·37  | nil.  | 1·03  | 4·16 | 0·06 | nil. | 6·77   |
|                  | Hoshangabad ...  | 5                | 1·01  | 0·72  | 0·01  | 0·01  | 2·90 | 0·96 | 0·07 | 5·68   |
|                  | Nursinghpore ... | 4                | 0·05  | 0·68  | 0·15  | 0·88  | 0·53 | 0·19 | nil. | 2·48   |
|                  | Nimar .....      | 3                | 0·06  | 0·44  | 0·14  | nil.  | 0·64 | 5·62 | 0·38 | 7·28   |

The chief peculiarity in the distribution of the rainfall was the contrast between the large amounts registered at stations to the south of the

line of advance, and those received at stations situated to the north of the path of the centre.

The following tables give the average district rainfall in the districts immediately to the south of the centre and those to the north of it for the same periods in the Central Provinces, Orissa, and the adjacent districts of South-west Bengal :—

| Districts to north of centre. | Total average rainfall June 27th to July 1st. | Districts in Orissa to south of centre. | Total average rainfall of the same period. |
|-------------------------------|---|---|--|
| 24-Pergunnahs .....           | 2.50  | Balasore .....                          | 8.47                                       |
| Midnapore .....               | 3.58  | Cuttack .....                           | 9.66                                       |
|                               |   | Pooree .....                            | 10.80                                      |

| Districts in the Central Provinces to north of the path of the centre. | Total district rainfall June 30th to July 2nd. | Districts of the Central Provinces through which the centre passed, or which lay to the south of the path of the centre. | Total district rainfall June 30th to July 2nd. |
|--|--|--|--|
| Bilaspore.....   | 1.12   | Sambalpur .....  | 2.31   |
| Mandla.....  | 0.28   | Raipore .....  | 2.90   |
| Jubbulpore .....   | 1.22   | Balaghat.....  | 3.21   |
| Narsinghpore .....   | 1.80   | Seoni .....  | 3.53   |
| Damoh.....   | 0.60   | Chindwara .....  | 5.25   |
| Saugor.....  | 0.41   | Hoshangabad.....   | 3.87   |
|  |  | Nagpur .....   | 6.13   |
|  |  | Bhandara .....   | 5.75   |
|  |  | Wardha .....   | 3.73   |
|  |  | Betul .....  | 5.24   |
|  |  | Nimar.....   | 6.26   |

The centre, it should be remembered, passed westwards near the northern boundaries of Sambalpur and Raipore and thence across the centre of the Balaghat, Seoni, Chindwara, and Hoshangabad districts. It will thus be seen that the rainfall was distinctly heaviest at some distance to the south of the path of the centre, and that the rainfall in the northern half of the cyclonic area was barely twenty-five per cent. of the amount received in the southern half.



It is not possible to give similar details for Central India and the northern districts of the Bombay Presidency. The following table gives the rainfall at the nearest meteorological observatories to the north and south of the path of the centre, and a glance will show that there was the same marked contrast between the rainfall in the northern and southern portions of the storm area during the latter part of its course, when it was approaching the Arabian Sea.

| Meteorological stations north of path of centre. | Total rainfall July 1st to 4th. | Meteorological stations south of path of centre. | Total rainfall July 1st to 4th. |
|--|---------------------------------|--|---------------------------------|
| Indore .....                                     | 1·92                            | Surat .....                                      | 5·80                            |
| Neemuch .....                                    | 1·16                            | Ahmedabad .....                                  | 5·43                            |
| Deesa .....                                      | 2·61                            | Malegaon .....                                   | 4·17                            |
| Ajmere .....                                     | 0·53                            | Bombay .....                                     | 1·09                            |
| Hyderabad .....                                  | 0·38                            | Rajkot .....                                     | 10·58                           |
| Kurrachee .....                                  | 2·00                            | Bhuj .....                                       | 5·82                            |

The previous peculiarities to a certain extent explain the striking contrast between the force of the wind in different quadrants, more especially when the storm was advancing over the sea or low ground. This has already been briefly referred to in the account of the meteorology of the present storm on the 28th and 29th (*vide* pages 86 and 93). It was there shown that the Pemba, at a distance of at least 200 miles to the south-east of the centre, had strong south-westerly winds of average force 9, which were frequently interrupted by excessively violent squalls; and that the ships and light-vessels, so long as they were in the western and northern quadrants, had winds from directions between N. W. and N. E. varying in force from 1 to 5, but that, when they passed in to the opposite quadrants, they experienced very violent westerly or south-westerly winds of force varying from 9 to 11.

This feature is shewn most strikingly by the anemometric observations taken at Saugor Island during the storm, which have been referred to in page 95, but are now given in full in illustration of this feature:—

| Date.       | Hour. | Barometer. | Wind.      |                                  | Weather and Sea.                                |
|-------------|-------|------------|------------|----------------------------------|---|
|             |       |            | Direction. | Amount during preceding 2 hours. |   |
| June 28th.. | 13    | 29.332     | N. N. E.   | 37                               | Sea rough. Threatening.<br>Dark gloomy weather. |
|             | 15    | .389       | N. E.      | 38                               |   |
|             | 17    | .287       | N. N. E.   | 45                               | Thunder and lightning at distance.              |
|             | 19    | .289       | N. N. E.   | 48                               | Raining.<br>Strong wind.                        |
|             | 21    | .327       | N.         | 43                               |   |
| June 29th.. | 23    | .286       | N. W.      | 54                               |   |
|             | 1     | .204       | W.         | 53                               | Raining.  |
|             | 3     | .126       | N. N. E.   | 27                               | Sea very rough.                                 |
|             | 5     | .176       | N.         | 37                               |   |
|             | 7     | .183       | N.         | 44                               |   |
|             | 9     | .171       | E.         | 18                               |   |
|             | 11    | .166       | E.         | 34                               |   |
|             | 13    | .126       | N. N. E.   | 54                               | Sea tremendous.                                 |
|             | 15    | .129       | W.         | 5                                |   |
|             | 17    | .162       | S.         | 78                               |   |
|             | 19    | .242       | S.         | 46                               |   |

Hence a prominent feature of this, as of many of the storms of the rains in the Bay, was excessively violent westerly and south-westerly winds in the southern and eastern quadrants and comparatively feeble winds in the northern and western quadrants. The great inequality of the winds in different quadrants in the majority of storms of the rains has caused them to be considered as mere westerly gales by seamen. It is, however, now proved beyond doubt that they are cyclonic disturbances in which the winds are rarely violent and dangerous except in the south and east quadrants, where westerly and south-westerly winds of force 8 to 10 may be experienced, interrupted by squalls as violent in character, so far as can be judged from the accounts of sailors, as are felt in the largest and most intense cyclones of the Bay.

The following additional illustrations are given of the difference of the force of the wind in the different quadrants of the cyclonic disturbance. It should, however, be remembered that it is difficult to explain many of

the differences in the amount of wind recorded at different stations apparently similarly situated with regard to the storm. They can only be ascribed either to erroneous reading of the anemometers by the observers at the stations under consideration, or to slight but influential differences in the geographical or topographical features of the districts or stations in which the meteorological observatories are situated. The latter appears to be the more probable explanation.

|         | Stations.         | Direction. | Average<br>wind<br>velocity<br>during<br>previous<br>24 hours. | Stations.           | Direction. | Average<br>wind<br>velocity<br>during<br>previous<br>24 hours. |
|---------|-------------------|------------|--|---------------------|------------|--|
| 28th... | Saugor Island ... | N. N. E.   | 8·0  | False Point .....   | W. S. W.   | 10·0   |
| 29th... | Saugor Island ... | E.         | 16·0   | False Point .....   | W. S. W.   | 23·0   |
| 30th    | Seoni .....       | N. W.      | 5·0  | Raipur .....        | W.         | 20·8   |
|         | Jubbulpore .....  | W. N. W.   | 6·0  | Cuttack .....       | W.         | 10·0   |
|         | Nagpur .....      | N. W.      | 9·0  | Saugor Island ..... | S. E.      | 19·0   |
|         |                   |            |  | Balasore.....       |            |  |
| 1st     | Seoni .....       | N. N. W.   | 15·0   | Raipur .....        | S. W.      | 20·0   |
|         | Jubbulpore .....  | N. N. E.   | 8·0  | Nagpur .....        | W.         | 11·0   |
|         | Sutna .....       | E.         | 21·0   | Sambalpure .....    | S. W.      | 1·4  |
|         |                   |            |  | Cuttack .....       | W.         | 7·0  |
| 2nd     | Indore .....      | N. E.      | 13·0   | Surat .....         | S. W.      | 17·0   |
|         | Jeypore .....     | N. E.      | 7·0  | Akola .....         | W.         | 22·0   |
|         | Ajmere .....      | E. N. E.   | 5·0  | Amraoti.....        | W. S. W.   | 43·0   |
|         | Saugor .....      | N. E.      | 11·0   | Khandwa .....       | W. S. W.   | 13·0   |
|         |                   |            |  | Nagpur .....        | S. W.      | 18·0   |
| 3rd     | Kurrachee.....    | N. N. W.   | 18·0   | Raipur .....        | S. W.      | 33·0   |
|         | Bhuj .....        | N. N. W.   | 3·0  | Neemuch .....       | S. S. W.   | 22·0   |
|         | Hyderabad .....   | N.         | 8·0  | Deesa .....         | S. E.      | 17·0   |

The contrast between the winds in different quarters is also evidenced by the amounts of wind received at the same station from different directions. Thus, at Saugor Island, the amount of wind registered for the 24 hours preceding 4 p. m. of the 28th was 192 miles, and for the same period prior to 4 p. m. of the 29th it was 524 miles. The wind during these intervals was from N. E. During the next 24 hours, when southerly winds chiefly prevailed, 776 miles were recorded. Similarly, at Balasore, 240 miles were registered for the 48 hours pre-

ceding 10 A. M. of the 29th, and 576 miles during the succeeding 48 hours (with southerly winds). At Rajkot, the amount of north-westerly winds during the 24 hours preceding 4 P. M. of the 2nd was 272 miles, and at Bhuj 390 miles. During the next 24 hours, when south-westerly winds blew at these stations, 391 and 760 miles respectively were registered. The amount of wind (mainly from N. W.) recorded at Kurrachee for the 24 hours preceding 4 P. M. on the 3rd was 406 miles. For the succeeding 24 hours, when easterly winds prevailed, 933 miles were registered.

There are other and less important features, to which it will be sufficient to refer briefly. One of these was the comparative smallness of the storm area proper. If we estimate it by the area in which strong winds prevailed and heavy rain fell, it almost certainly did not exceed 250 miles in length by 100 to 150 miles in breadth, at any time during its passage across the continent. The smallness of the storm area and the slight barometric depression in all storms of the rains are cognate features due probably to the peculiar conditions of their formation, as cyclones of high elevation. Another feature was the very great irregularity of the winds. This was shown (at Saugor Island, for instance) by intervals of comparatively feeble winds during the middle of the storm, and also by the apparent occurrence of much feebler winds at stations nearer to the centre than at those at a greater distance. As, however, anemometric observations are confessedly not intercomparable, it is not possible to establish the fact of this irregularity on such evidence.

#### APPENDIX I.

*Extract from the Log of the F. L. V. Comet, giving observations during Storm of June 27th to 30th.*

| Date.              | Hour. | Wind.      |        | Barometer reduced. | Weather. | REMARKS.   |
|--------------------|-------|------------|--------|--------------------|----------|--|
|                    |       | Direction. | Force. |                    |          |  |
| 28th of June 1882. | 8     | N.         | 4      | 29.321             | Thunder. | Commences with dirty threatening weather. Lightning all round the horizon. A long heavy swell from E. S. E. 3 A. M. Squally with passing showers, ugly appearance of weather.<br>8 A. M. Weather the same. A large circle round the sun. |



| Date.              | Hour. | Wind.      |        | Barometer reduced. | Weather. | REMARKS.  |
|--------------------|-------|------------|--------|--------------------|----------|---|
|                    |       | Direction. | Force. |                    |          |   |
| 28th of June 1833. | 9     | N. N. E.   | 4      | 29.327             |          |   |
|                    | 10    | N. E.      | 4      | 29.327             | Raining. |   |
|                    | 11    | ...        | 3to5   | 29.308             |          |   |
|                    | 12    | ...        | 4to6   | 29.277             | Thunder. | Noon. Every appearance of a cyclone. Heavy confused sea, with squally weather, and passing showers and thunder.                               |
|                    | 13    |            |        | 29.266             |          |   |
|                    | 14    | ...        | 6to5   | 29.252             | Thunder. |   |
|                    | 15    |            |        | 29.241             |          |   |
|                    | 16    | ...        | 5      | 29.215             | Squally. | 4 P. M. Wind and weather the same. Observed the sky of dark red appearance to the southward and eastward.                                     |
|                    | 17    |            |        | 29.220             |          |   |
|                    | 18    | N.         | 5      | 29.226             | Squally. |   |
|                    | 19    |            |        | 29.230             |          |   |
|                    | 20    | ...        | 5      | 29.253             | Thunder. | 8 P. M. Wind and weather the same.  |
|                    | 21    | ...        |        | 29.260             |          |   |
|                    | 22    | N. N. W.   | 5      | 29.236             | Thunder. |   |
| 29th of June 1833. | 23    |            |        | 29.197             |          |   |
|                    | 24    | N. W.      | 6      | 29.195             | Thunder. | Midnight. Wind and weather the same. Barometer still falling, every appearance of heavy weather. Thunder and lightning all round the horizon. |
|                    | 1     | W. N. W.   | 6      | 29.148             |          | Commences with dirty and very threatening weather. Lightning all round the horizon. A very heavy sea running from S. E. Winds variable.       |
|                    | 2     | N. N. E.   | 6      | 29.070             | Raining. |   |
|                    | 3     | ...        | 6      | 29.094             |          |   |
|                    | 4     | ...        | 5      | 29.074             | Thunder. |   |
|                    | 5     | N. N. W.   | 5to6   | 29.112             |          |   |
|                    | 6     | ...        | 6      | 29.126             | Squally. |   |
|                    | 7     | ...        | 6      | 29.138             |          |   |

| Date.              | Hour. | Wind.      |        | Barometer reduced. | Weather.  | REMARKS.  |
|--------------------|-------|------------|--------|--------------------|-----------|---|
|                    |       | Direction. | Force. |                    |           |   |
| 29th June 1883.    | 8     | W.         | 6      | 29.120             | Squally.  | 8 A. M. Wind and weather the same, but sea increasing. Wind shifting all round the compass, from west through south and east, accompanied with terrific rain squalls. |
|                    | 9     |            |        | 29.122             |           |   |
|                    | 10    | S. S. E.   | 3      | 29.140             | Squally.  |   |
|                    | 11    |            |        | 29.086             |           |   |
|                    | 12    | E. N. E.   | 7      | 28.998             | Raining.  | Noon. Blowing a furious gale with terrific heavy squalls. Sea still increasing and barometer falling.   |
|                    | 13    | N. N. W.   | 8      | 28.989             | Raining.  |   |
|                    | 14    | W.         | 8      | 29.068             | Raining.  |   |
|                    | 15    | ...        | 8      | 29.088             | Raining.  |   |
|                    | 16    | S. W.      | 9      | 29.108             | Raining.  | 4 P. M. Wind and weather the same.  |
|                    | 17    | S. S. W.   | 9      | 29.184             | Raining.  |   |
|                    | 18    | S. W.      | 9      | 29.184             | Raining.  |   |
|                    | 19    | S. S. W.   | 9      | 29.164             | Raining.  |   |
|                    | 20    | ...        | 9      | 29.247             | Raining.  | 8 P. M. Wind and weather the same.  |
|                    | 21    | S. S. W.   | 9      | 29.288             | Raining.  |   |
|                    | 22    | ...        | 9      | 29.306             | Raining.  |   |
|                    | 23    | ...        | 9      | 29.320             | Raining.  |   |
| 30th of June 1883. | 24    | ...        | 9      | 29.326             | Raining.  | Midnight. Weather more moderate, less wind and sea.   |
|                    | 1     | S. S. W.   | 7      | 29.324             | Raining.  |   |
|                    | 2     | "          | 7      | 29.336             | Raining.  |   |
|                    | 3     | "          | 7      | 29.346             | Raining.  |   |
|                    | 4     | "          | 7      | 29.353             | Raining.  | Commences with moderate gale and high sea but better appearance in the weather.   |
|                    | 5     | "          | 7      | 29.356             | Raining.  |   |
|                    | 6     | "          | 7      | 29.361             | Overcast. |   |
|                    | 7     | S.         | 8      | 29.365             | Overcast. |   |
|                    | 8     | "          | 8      | 29.415             | Raining.  | 8 A. M. Observed a large circle round the sun.  |
|                    | 9     | "          | 8      | 29.440             | Raining.  |   |
|                    | 10    | "          | 8      | 29.474             | Overcast. |   |
|                    | 11    | "          | 6      | 29.486             | Overcast. |   |
|                    | 12    | "          | 6      | 29.464             | Raining.  | Noon. Strong breezes with blinding rain squalls.  |
|                    |       |            |        |                    |           |   |
|                    |       |            |        |                    |           | P. M. Weather fine. Heavy swell from southward.   |

## CHAPTER IV.

## THE HISTORY OF THE STORM OF THE 10TH TO 15TH NOVEMBER, 1883.

The present storm was generated in the Gulf of Martaban, after the north-east monsoon had been established for more than a month over the north and centre of the Bay. The rains of the south-west monsoon terminated prematurely in Bengal in the last week of September. It is a well-known fact that the commencement of the north-east monsoon on the Coromandel coast is due to the recurvature of the south-west monsoon winds over the south and centre of the Bay. The lower atmospheric current, which is from south-west in the extreme south, at that period changes, through south-east and east in the centre of the Bay, to north-east on the Madras coast. The south-west monsoon current of the year 1883 was unusually weak, and, when it retreated from Bengal, it recurved immediately, and north-east winds were established on the Madras coast in the first week of October. Hence the north-east monsoon rains set in over the Madras Presidency a week or ten days earlier than usual. They gave general, and unusually heavy, rainfall, as is shown by the following table of rainfall at eight of the more important stations in that Presidency.

*Rainfall at eight stations of the Madras Presidency, October 1883.*

| Stations.     | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Cocona-da ... | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 1.62 | 2.35 | 0.10 | 0.23 | 1.50 |
| Masuli-patam  | 0.30 | ...  | ...  | 0.18 | 0.13 | ...  | ...  | 0.02 | ...  | ...  | ...  | ...  | 0.75 | 2.44 | ...  | 1.47 | 0.31 |
| Madras        | ...  | 4.88 | 0.20 | 0.34 | ...  | 0.01 | 0.08 | ...  | ...  | ...  | 0.48 | 0.36 | 1.81 | 1.51 | 1.06 | 3.40 | 0.57 |
| Salem...      | ...  | ...  | 2.75 | ...  | 0.20 | 0.15 | ...  | ...  | ...  | 0.01 | 1.05 | 0.75 | 0.14 | 0.66 | 1.04 | 1.83 | 0.80 |
| Nellore       | ...  | 0.50 | 0.35 | ...  | ...  | ...  | 0.05 | 0.15 | ...  | ...  | ...  | 0.50 | 0.60 | 4.45 | 0.95 | 0.45 | 2.20 |
| Madura        | ...  | ...  | 0.05 | 0.04 | 0.35 | ...  | ...  | ...  | 0.45 | ...  | ...  | 2.10 | 0.26 | 0.20 | 2.16 | 0.34 | 0.13 |
| Trichi-nopoly | ...  | ...  | 0.43 | 1.55 | ...  | ...  | ...  | ...  | ...  | 0.70 | ...  | ...  | 0.10 | 0.26 | 0.46 | 0.63 | ...  |
| Tanjore       | ...  | 1.04 | ...  | 0.47 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 0.06 | ...  | 1.47 | 0.83 | 0.10 | ...  |

| Stations.     | 18   | 19   | 20   | 21   | 22   | 23   | 24   | 25   | 26   | 27   | 28   | 29   | 30   | 31   | Total. | Average. |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|--------|----------|
| Cocona-da ... | 0.66 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 0.90 | 0.25 | 5.70 | 13.31  | 8.60     |
| Masuli-patam  | 0.28 | ...  | 0.21 | 0.05 | 0.01 | ...  | 0.24 | 0.03 | ...  | ...  | 0.03 | 1.25 | 0.70 | 4.95 | 13.35  | 8.58     |
| Madras        | 0.16 | 0.10 | 0.12 | 0.37 | ...  | ...  | ...  | 0.02 | 0.16 | 2.89 | 2.12 | 1.54 | ...  | ...  | 22.18  | 10.80    |
| Salem...      | ...  | 1.27 | ...  | 0.08 | ...  | ...  | ...  | ...  | 0.40 | 0.35 | ...  | ...  | ...  | 0.96 | 12.44  | 7.22     |
| Nellore       | 0.30 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 0.15 | ...  | ...  | 2.55 | 8.20 | 3.00 | 24.40  | 9.84     |
| Madura        | ...  | 0.41 | ...  | 0.07 | ...  | 0.50 | ...  | 1.35 | ...  | 0.25 | 0.12 | ...  | ...  | 0.20 | 8.98   | 8.88     |
| Trichi-nopoly | ...  | 2.47 | ...  | 0.46 | ...  | ...  | ...  | ...  | ...  | 0.10 | 0.09 | ...  | ...  | 0.69 | 7.94   | 7.86     |
| Tanjore       | 0.08 | 0.06 | 1.70 | ...  | ...  | ...  | ...  | ...  | 0.20 | 0.60 | ...  | 0.05 | ...  | 0.20 | 6.86   | 5.60     |

*Rainfall at eight stations of the Madras Presidency, November 1883.*

| Stations.    | 1     | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12  | 13  | 14  | 15  |
|--------------|-------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|
| Coconada...  | 6.45  | 3.25 | 0.22 | ...  | 0.05 | ...  | ...  | ...  | ...  | ...  | ...  | ... | ... | ... | ... |
| Masulipatam  | 12.56 | 2.29 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ... | ... | ... | ... |
| Madras       | 1.87  | 2.46 | 2.12 | 1.15 | 0.27 | 0.12 | 0.14 | 0.41 | 0.02 | ...  | ...  | ... | ... | ... | ... |
| Salem...     | 0.73  | 0.94 | 0.27 | 1.16 | 0.16 | ...  | 0.02 | 0.01 | 0.75 | 0.06 | ...  | ... | ... | ... | ... |
| Nellore      | 1.00  | 1.60 | 0.45 | 0.60 | 0.05 | 0.95 | ...  | ...  | ...  | ...  | ...  | ... | ... | ... | ... |
| Madura       | 1.95  | 1.80 | 1.08 | 3.00 | ...  | 0.20 | 0.04 | 0.03 | ...  | 0.33 | 2.00 | ... | ... | ... | ... |
| Trichinopoly | ...   | 0.06 | 0.25 | 1.96 | ...  | ...  | 1.44 | ...  | 0.10 | ...  | ...  | ... | ... | ... | ... |
| Tanjore      | ...   | 0.27 | 0.08 | 1.78 | 1.02 | 0.06 | ...  | 0.85 | ...  | ...  | ...  | ... | ... | ... | ... |

| Stations.    | 16  | 17   | 18   | 19   | 20   | 21   | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  | Total. | Average. |
|--------------|-----|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|----------|
| Cocanada...  | ... | ...  | ...  | ...  | ...  | ...  | ... | ... | ... | ... | ... | ... | ... | ... | ... | 9.97   | 3.59     |
| Masulipatam  | ... | ...  | ...  | ...  | ...  | ...  | ... | ... | ... | ... | ... | ... | ... | ... | ... | 14.85  | 4.11     |
| Madras       | ... | ...  | 0.30 | 4.75 | 1.31 | ...  | ... | ... | ... | ... | ... | ... | ... | ... | ... | 14.92  | 13.40    |
| Salem...     | ... | ...  | 0.25 | 0.01 | ...  | ...  | ... | ... | ... | ... | ... | ... | ... | ... | ... | 4.36   | 2.65     |
| Nellore      | ... | ...  | 0.55 | 0.70 | ...  | ...  | ... | ... | ... | ... | ... | ... | ... | ... | ... | 5.90   | 10.17    |
| Madura       | ... | ...  | 0.20 | ...  | ...  | 0.35 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 10.98  | 5.37     |
| Trichinopoly | ... | 1.26 | ...  | 0.08 | 0.07 | ...  | ... | ... | ... | ... | ... | ... | ... | ... | ... | 5.22   | 5.23     |
| Tanjore      | ... | ...  | 2.90 | 0.02 | 0.17 | 0.48 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 7.63   | 5.54     |

The preceding table shews that rain fell more or less continuously during the whole of October and until the 4th of November, after which a few showers fell until the 9th and 10th, when rain entirely ceased for several days. After the 4th, the north-east monsoon current decreased



in strength, as is shewn by the following return of the wind observations on the Madras coast :—

|              | November average. |         | 1st. |         | 2nd. |         | 3rd. |         | 4th. |         | 5th. |         | 6th. |         | 7th. |         |
|--------------|-------------------|---------|------|---------|------|---------|------|---------|------|---------|------|---------|------|---------|------|---------|
|              | Dir.              | Amount. | Dir. | Amount. | Dir. | Amount. | Dir. | Amount. | Dir. | Amount. | Dir. | Amount. | Dir. | Amount. | Dir. | Amount. |
| Vizagapatam. | N83°E             | 2.5     | N    | 2       | N    | 1       | N    | 3       | N    | 3       | NE   | 3       | N    | 4       | NE   | 2       |
| Masulipatam. | N56°E             | 6.0     | NNE  | 9       | SE   | 9       | ENE  | 6       | ENE  | 9       | ENE  | 7       | NE   | 8       | NNE  | 7       |
| Madras.      | N24°E             | 6.8     | WSW  | 5       | SE   | 6       | SE   | 7       | NNE  | 5       | N    | 5       | N    | 6       | E    | 4       |
| Negapatam.   | N37°E             | 5.6     | SW   | ?       | SW   | 0       | WNW  | ?       | NE   | ?       | NNE  | 2       | NE   | 4       | NNE  | 6       |

The preceding observations shew that the north-east winds on the Madras coast were diminishing in force. It is, therefore, probable that the south-west monsoon current over the south of the Bay was much weaker, and that, instead of recurving and blowing strongly on the Madras coast, it was continued over the centre of the Bay as light and variable winds. This supposition is, it will be seen, confirmed by the accounts of the weather contained in the logs of the vessels navigating the Bay to the west of the Andamans at that time. The cyclone did not commence to form until the 9th of November, but the meteorology of the Bay on the 7th and 8th is given to shew the character of the weather prior to the storm.

*7th November.*—The barometer was oscillating at the time slowly over the whole of India, and the distribution of pressure was almost identical with that which had obtained for the previous three or four days, and differed very slightly from the normal. A slight rise of the barometer occurred during the previous 24 hours at the great majority of stations. The barometric changes were, however, of no importance. The barometer was highest in Scind and Rajputana, where the readings averaged 30.05", and was lowest over the south of the Bay, where, as shown by the returns of Negapatam, Trincomalee, Port Blair, and Nancowry, it was slightly below 29.95". The differences of pressure were hence comparatively small over the whole area.

The following table gives the 10 A. M. readings of the barometer,

reduced to sea level and for temperature, at the more important meteorological stations around the Bay :—

| Stations.           | Barometer<br>at 10 A. M.<br>reduced to<br>sea level. | Stations.            | Barometer<br>at 10 A. M.<br>reduced to<br>sea level. |
|---------------------|--|----------------------|--|
| Saugor Island ..... | 30·028   | Chittagong .....     | 29·994   |
| False Point .....   | 30·028   | Akyab .....          | 29·975   |
| Gopaulpore .....    | 30·016   | Diamond Island ..... | 29·970   |
| Vizagapatam .....   | 30·014   | Port Blair.....      | 29·945   |
| Madras .....        | 30·013   | Nancowry.....        | 29·943   |
| Negapatam .....     | 29·948   | Moulmein .....       | 29·958   |
| Trincomalee .....   | 29·951   | Rangoon .....        | 30·004(?)  |
|                     |  | Mergui .....         | 29·956   |

The gradients over the Bay were normal in character, pressure decreasing from north to south. The total barometric difference was slightly less than nine-hundredths of an inch. The average barometric difference between the north and south of the Bay in the middle of November is '075". The distribution of pressure over the Bay on the 7th was very approximately normal.

Over the greater part of India, including the whole of Northern and Central India and the North Deccan, the weather was fine and skies clear. These were clouded in Southern India, more especially on the Coromandel coast, where they were generally overcast. Over the whole of the Indian land area, winds were normal in direction. North-westerly to westerly winds prevailed over the greater part of the Gangetic plain, and northerly winds in the Gangetic Delta. Along and near the Coromandel coast, north-easterly humid winds were giving moderate showers of rain. In Burmah, winds varying between east and north-east prevailed. The weather in every part of the Indian area, so far as can be judged from the land observations, was of the usual November, or cold weather, type. There were no signs of the existence of any atmospheric disturbance either in the land or adjacent sea area.

The only indications of the probable early occurrence of stormy weather in the Bay were the lightness and variability of the winds over the centre and south of the Bay, and the rapid and steady decrease in the rainfall of the Madras Presidency.

The following table gives the chief observations taken during the day at the stations subsequently affected by the cyclone:—

| Stations.        | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind direction. |          | Velocity in miles per hour since 10 A. M. previous day. | Cloud amount at 10 A. M. | Rainfall at 10 A. M. preceding 24 hours. | Weather.            |
|------------------|---|-------------------------------------|-----------------|----------|---|--------------------------|--|---------------------|
|                  |   |                                     | 10 A. M.        | 4 P. M.  |   |                          |  |                     |
| Nancowry .....   | 29·943                                      | + ·041                              | S.              | S.S.W.   | 4   | 6                        | 0·62                                     |                     |
| Port Blair ..... | 29·945                                      | + ·003                              | S. E.           | S. E.    | 4   | 7                        | ...                                      |                     |
| Diamond Island   | 29·970                                      | + ·033                              | E. N. E.        | E.       | 5   | 5                        | 0·11                                     | Thunder.            |
| Akyab .....      | 29·975                                      | + ·027                              | E. N. E.        | W.       | 2   | 1                        | ...                                      | Fine.               |
| Chittagong ...   | 29·994                                      | + ·027                              | N. N. E.        | E.       | 2   | 1                        | ...                                      | Fine.               |
| Toung'hoo .....  | 29·969                                      | + ·081                              | N. W.           | N. W.    | ?   | 10                       | ...                                      | Threatening weather |
| Bassein .....    | 20·977                                      | + ·037                              | E.              | S. E.    | 4   | 10                       | 0·02                                     | Gloomy.             |
| Rangoon .....    | 30·004?                                     | + ·068                              | E. N. E.        | E. N. E. | 3   | 10                       | 0·28                                     | Cloudy.             |
| Moulmein .....   | 29·958                                      | + ·073                              | E.              | N. N. W. | 2   | 9                        | ...                                      | Cloudy.             |
| Mergui .....     | 29·956                                      | + ·015                              | N.              | Calm     | 1   | 6                        | ...                                      | Cloudy.             |

The information relating to the state of the weather in the Bay on the 7th of November, contained in the logs of vessels navigating the Bay at this period, is given in the following statement:—

| Vessel.            | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable reduced barometer. | Wind.     |        | REMARKS.  |
|--------------------|---------|-----------------|------------------|-----------------------------|-----------|--------|---|
|                    |         |                 |                  |                             | Dir.      | Force. |   |
| Mount Stuart ..... | Noon    | 11° 50'         | 91° 50'          | 29·925                      | E.        | ...    | Passing clouds towards noon, heavy rain clouds all round, but cleared away towards sunset. Weather unsettled-looking. |
|                    | 4 P. M. |                 |                  |                             | E.        | 2      |   |
|                    | 8 P. M. |                 |                  |                             | variable. | 3      |   |
|                    | Midnt.  |                 |                  |                             | S.        | ...    |   |
| Kwang Tung         | 4 A. M. |                 |                  | 29·851                      | S. E.     | 2      | Fine weather throughout.  |
|                    | 8 A. M. |                 |                  | ·909                        | N. E.     | 2      |   |
|                    | Noon    | 12° 33'         | 93° 6'           | ·943                        | N. E.     | 2      | Sea smooth.   |
|                    | 4 P. M. |                 |                  | ·921                        | N. E.     | 2      |   |
|                    | 8 P. M. |                 |                  | ·909                        | N. E.     | 2      |   |
|                    | Midnt.  |                 |                  | ·906                        | S. W.     | 2      |   |

| Vessel.                   | Hour.   | Latitude.<br>N. | Longitude. | Probable<br>reduced<br>barometer. | Wind.    |          | REMARKS.  |
|---------------------------|---------|-----------------|------------|-----------------------------------|----------|----------|---|
|                           |         |                 |            |                                   | Dir.     | Force.   |   |
| Frank Staf-<br>ford ..... | 4 A. M. |                 |            |                                   | N.       | 4        | Fine weather and<br>smooth sea.   |
|                           | Noon    | 19° 43'         | 88° 15'    | 29.980                            | N.       | 4        |   |
|                           | Midnt.  |                 |            |                                   | N.       | 4        |   |
| Parthenope                | Noon    | 20° 10'         | 89° 51'    | 29.975                            | N.       | Moderate | A. M. Light unsteady<br>breeze, fine, and clear.<br>Noon. Wind very un-<br>steady. Current per-<br>ceptible, setting to the<br>S. W. 4 P. M. Moderate<br>breeze. 8 P. M. Light<br>breeze and clear, with<br>frequent lightning. |
|                           | Midnt.  |                 |            |                                   | N. W.    | Light.   |   |
| Breadalbane               | Noon    | 20° 55'         | 88° 8'     | 29.975                            | N. N. E. | 0 to 1   | Calm and variable airs<br>throughout, current to<br>S. W.   |
|                           | 4 P. M. |                 |            |                                   | NE by N  | 2 to 3   |   |

The information respecting the weather in the Bay is very limited, and confined to extracts from the logs of five vessels, and to the observations at Port Blair, Nancowry, the coast stations, and on board the light vessels near the entrance to the Hooghly.

Three vessels, the Frank Stafford, Parthenope, and Breadalbane, were near the Head of the Bay. The weather was fine, the sea smooth, and winds light and unsteady. These varied between N. E. and N. W. in direction, and did not exceed force 4 at any time during the day. At Port Blair, the sky, which had been almost clear on the 4th, 5th, and 6th, was clouding over. The air was unusually clear in the morning, but the weather became cloudy and gloomy in the afternoon. No rain fell on this day, nor had any fallen since the 4th. The winds also were extremely light. Only 100.6 miles were registered for the 24 hours preceding 4 P. M., the smallest amount in 24 hours recorded during the month.

The sky had been densely clouded at Nancowry for some days past, and rain in moderate amounts had been recorded on every day. On the 6th .62 inch fell with S. S. W. winds. During the first three days of the month, the winds were from south-east, the normal direction



in November, when the south-west monsoon is recurving over the centre of the Bay, and giving north-easterly monsoon winds and rain to the Coromandel coast. The amount of wind registered at Nancowry on each day of the first week of the month, is given in the following table :—

|                       | Total wind<br>amount of the<br>24 hours previ-<br>ous to 4 P. M. | Rainfall at<br>6 P. M. of the<br>preceding 24<br>hours. | Wind direction<br>10 A. M. |
|-----------------------|--|---|----------------------------|
| 1st .....             | 46·7   | 0·47  | S. E.                      |
| 2nd .....             | 38·2   | 0·21  | S. E.                      |
| 3rd .....             | 44·0   | 2·86  | E. S. E.                   |
| 4th .....             | 19·5   | 0·41  | S. W.                      |
| 5th .....             | 18·8   | 0·96  | S. W.                      |
| 6th .....             | 17·1   | 0·62  | S. W.                      |
| 7th .....             | 125·4  | 1·14  | S. S. W.                   |
| Average October ..... | 149·7  | ...   | S. 50° W.                  |
| „ November ...        | 117·2  | ...   | S. 29° E.                  |

This shows that, in consequences of atmospheric actions, the nature of which can only be conjectured, the air motion over the south of the Bay was unusually and remarkably feeble during the first week of the month. The moist current advancing northward, instead of curving through south-east and east and arriving as north-east winds charged with vapour on the Coromandel coast, was exceedingly weak for some days in the neighbourhood of the Nicobars. It had also shifted in direction on the 4th, and was proceeding from the south-west directly into the Martaban Gulf. Rain also began to fall in increasing amounts over this and the adjacent parts of the Bay.

The ship *Mount Stuart* was advancing northwards, a little distance to the west of the Andamans. She was in Lat. 11° 50' N. and Long. 91° 50' at noon, and during the day had very variable winds commencing from N. E. by N. and ending at S. The weather was fine, but the air was charged with moisture. This is shown by the fact, noted by the Captain, that, during the hotter part of the day, when there is undoubtedly much upward movement of the air, heavy rain clouds formed all around, but cleared away again towards sunset.

The *Kwang Tung*, on the other hand, was to the east of the Andamans in Lat. 12° 33' N. and Long. 93° 6' E. She had fine weather throughout, with light and variable winds during the day of force 2. The wind shifted from S. E. to N. E. and thence to S. W. during the day.

Hence, so far as can be judged from the various meteorological returns, light winds and fine weather prevailed over the greater part of the Bay. The usual change in the direction or recurvature of the south-west monsoon current (which gives a feeble cyclonic circulation to the air over the centre and south of the Bay) was not only much weaker than usual, but was suspended over a part of the area in the neighbourhood of the Nicobars and Andamans, where very light unsteady winds had prevailed for the previous two or three days. There is, however, no evidence in the meteorology of this day of the existence of any local cyclonic circulation, such as might form the initial stage in the development of a cyclonic disturbance or storm.

The observations at Moulmein and Mergui confirm the previous statements, and prove the existence of light variable winds, chiefly from the east and north, on the east coast of the Martaban Sea.

*8th November.*—During the preceding 24 hours, a rapid fall of the barometer had taken place in the Punjab. The amount of the fall was '26" at Mooltan, '13" at Quetta, and '12" at Dera Ismail Khan and Lahore.

It will be seen from the meteorology of the 9th and 10th that this fall was the first indication of the occurrence of a cold weather or north-east monsoon storm in Upper India. It is during these storms that a large portion of the snowfall of the higher Himalayas takes place. In consequence of this rapid fall, pressure was lowest over the Punjab. Sudden and large changes of pressure are a frequent feature of the cold weather in the Punjab. It is not yet quite certain whether the formation of these Punjab areas of low pressure commences simultaneously over the Western Punjab and the adjacent districts of Afghanistan or Belochistan. This appears to be the most probable explanation, but it is not unlikely that some may occasionally form much further to the west, and pass through Afghanistan or Belochistan into the Punjab or Sind. It will, however, presently be seen that this considerable disturbance in the Punjab exercised no appreciable action on the atmospheric circulation in the Bay of Bengal.

The distribution of pressure was somewhat complicated over India itself. Pressure was lowest in the Indus Valley. A broad band of high pressure stretched down the middle of India from Ajmere to Secunderabad, whilst pressure was approximately uniform over the Bay.

The changes of pressure were not accompanied by any immediate marked change in the wind or weather. Skies were clear, and weather fine and dry over all parts of India, except South Burmah and Southern India (more especially the Coromandel Coast), where skies were overcast and occasional showers continued to be received. The amounts which fell at the various rainfall registering stations were very small.

The only alteration in the wind directions that deserves notice occurred at Diamond Island and Akyab, where the wind had shifted round to south-east. This of course indicated the further northward extension of the south-west monsoon current which had commenced on the 4th at Nancowry.

The following table gives the 10 A. M. reduced barometric readings of the recording stations on the coast of the Bay :—

| Stations on west coast of the Bay. |   | Stations on east coast of the Bay. |   |
|------------------------------------|---|------------------------------------|---|
| Stations.                          | Barometer<br>10 A. M.<br>reduced to<br>sea level. | Stations.                          | Barometer<br>10 A. M.<br>reduced to<br>sea level. |
| Sangor Island .....                | 29·977  | Chittagong .....                   | 29·953  |
| False Point .....                  | 29·983  | Akyab .....                        | 29·930  |
| Vizagapatam .....                  | 29·976  | Diamond Island .....               | 29·930  |
| Madras .....                       | 29·983  | Moulmein .....                     | 29·928  |
| Negapatam .....                    | 29·978  | Port Blair .....                   | 29·936  |
|                                    |   | Nancowry .....                     | 29·922  |

The differences of pressure along the west coast were much smaller than on the 7th, and pressure was very approximately uniform. It was slightly lower at the east coast stations, but, even there, the differences were extremely small.

The following table gives the 10 A. M. observations at stations in the neighbourhood of the area in which the storm was generated :—

| Stations.        | Barometer at<br>10 A. M. re-<br>duced to sea<br>level. | Change since<br>10 A. M. pre-<br>vious day. | Wind direction. |          | Velocity in<br>miles per hour<br>since 10 A. M.<br>previous day. | Cloud amount<br>at 10 A. M. | Rainfall at 10<br>A. M. preced-<br>ing 24 hours. | Weather.             |
|------------------|--|---|-----------------|----------|--|-----------------------------|--|----------------------|
|                  |  |   | 10 A. M.        | 4 P. M.  |  |                             |  |                      |
| Nancowry .....   | 29·922   | —·021                                       | S. W.           | S. W.    | 7  | 10                          | 1·14   | Thunder.             |
| Port Blair ..... | 29·936   | —·009                                       | W. S. W.        | W. S. W. | 5  | 9                           | 0·18   |                      |
| Diamond Island   | 29·930   | —·040                                       | E. S. E.        | S.       | 13   | 10                          | 2·35   |                      |
| Akyab .....      | 29·930   | —·045                                       | S. S. E.        | ?        | 2  | 6                           | 0·16   |                      |
| Chittagong ...   | 29·953   | —·041                                       | N.              | E. S. E. | 1  | 0                           | ...  |                      |
| Toungoo .....    | 29·980   | +·011                                       | S. W.           | S. E.    | ?  | 10                          | ...  | Showery.<br>Thunder. |
| Bassein .....    | 29·941   | —·036                                       | S. E.           | S. S. E. | 4  | 10                          | 0·10   |                      |
| Rangoon .....    | 29·965   | —·039                                       | E.              | S. S. E. | 2  | 10                          | 0·41   |                      |
| Moulmein .....   | 29·928   | —·030                                       | S. E.           | N. W.    | 2  | 7                           | ...  |                      |
| Mergui .....     | 29·965   | +·009                                       | E.              | S.       | 2  | 10                          | 0·25   |                      |

The information relating to the meteorology of the Bay on the 8th is given in the following table :—

| Vessels.             | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.   |         | REMARKS.  |
|----------------------|---------|-----------------|------------------|---------------------------------------|----------|---------|---|
|                      |         |                 |                  |                                       | Dir.     | Force.  |   |
| Mount Stuart         | 4 A. M. |                 |                  |                                       | S. to W. | 2 to 3  | Sea smooth. Passing showers during day. Heavy black clouds all round, with momentary puffs from N. W., and smart showers towards midnight. There was lightning in the N. W. during the morning. Midnight. Weather was a little squally. |
|                      | Noon    | 12° 17'         | 92° 00'          | 29.925                                | ...      | 1 to 2  |   |
|                      | 4 P. M. |                 |                  |                                       | W to SE. | 1       |   |
|                      | Midnt.  |                 |                  |                                       | W to NW  | 2 to 4  |   |
| Scottish Hill        | Noon    | 12° 31'         | 89° 25'          | 29.920                                | E. to W. | 1       | Light airs and calms. Wind very variable. Sky dull lead colour.   |
|                      | 4 P. M. |                 |                  |                                       |          | 0       |   |
|                      | 8 P. M. |                 |                  |                                       |          | 0       |   |
|                      | Midnt.  |                 |                  | 29.900                                |          | 1       |   |
| Kwang Tung           | 4 A. M. |                 |                  | 29.901                                | N. W.    | 2       | Smooth sea.   |
|                      | 8 A. M. |                 |                  | .926                                  | N. W.    | 2       |   |
|                      | Noon    | 15° 11'         | 92° 6'           | .893                                  | N. W.    | 2       |   |
|                      | 4 P. M. |                 |                  | .901                                  | N. W.    | 4 to 5  |   |
|                      | 8 P. M. |                 |                  | .871                                  | N. W.    | do.     |   |
|                      | Midnt.  |                 |                  | .903                                  | N. W.    | do.     |   |
| Frank Staf-<br>ford. | 4 A. M. |                 |                  |                                       | NW by N  | 2       | Fine weather, smooth sea. Very sharp lightning in the S. E. during the night.   |
|                      | 8 A. M. |                 |                  |                                       | North.   | 2       |   |
|                      | Noon    | 20° 16'         | 90° 28'          | 29.975                                | N. N. W. | 2       |   |
|                      | 8 P. M. |                 |                  |                                       | N. N. W. | 1       |   |
| Breadalbane          | Midnt.  |                 |                  |                                       | N. N. W. | 0       |   |
|                      |         |                 |                  |                                       |          |         |   |
| Parthenope           | Noon    | 21° 00'         | 88° 18'          | 29.975                                | N.       |         | Sunrise. Moderate breeze from N., dying away in the afternoon to a calm.  |
|                      |         |                 |                  |                                       |          |         |   |
| Parthenope           | Noon    | 21° 2'          | 88° 52'          | 29.975                                | N. W.    | gentle. | A. M. Light breeze, fine and clear. 8 A. M. Moderate breeze and hazy. Noon. Less wind, current setting west. 4 P. M. Light airs. 8 P. M. Calm. Midnight. Gentle breeze and clear.   |
|                      | Midnt.  |                 |                  |                                       | N. by E. |         |   |



The Nancowry returns prove that the south-west winds in the neighbouring part of the Bay began to increase in strength. The sky was overcast during the day, and 1·14 inches of rain were registered for the 24 hours preceding 1 p. m. The wind during the previous night had shifted round to W. S. W. at Port Blair, and blew steadily during the day, and somewhat more strongly than on either of the previous two days. The sky had clouded over, and rain in small amounts began to fall. ·18 inch was recorded at 4 p. m.

The weather was slightly disturbed in South Burmah. Passing showers fell during the day, and thunderstorms occurred in one or two cases. East-south-east winds set in at Diamond Island and at Rangoon. In the interior of Burmah, winds were not so steady as they had been previously. The sky was overcast at Mergui, winds were light and variable, and veered from east to south during the day.

The prevalence of S. W. winds at Port Blair and Nancowry, and of E. and S. E. winds at the Burmah stations, shews that there was on this day no well-defined cyclonic circulation, or centre of large disturbance, in the Martaban Gulf.

The logs of the vessels in the Bay for the day indicate that similar conditions obtained to those of the preceding day.

The Frank Stafford, Parthenope, and Breadalbane were at the Head of the Bay near the entrance to the Hooghly. They experienced fine weather, light winds and calms, and a smooth sea. The Kwang Tung had steamed to the north-west during the previous 24 hours, and was in Lat. 15° 11' N. and Long. 92° 6' E. at noon. Her log shows that there was no perceptible current in this part of the Bay at this time, an almost conclusive proof of the absence of any strong atmospheric cyclonic circulation in the neighbourhood. The ships Mount Stuart and Scottish Hill were a little to the west of the Andamans. The former was in Lat. 12° 17' N. and Long. 92° E. Her log states that the sea was smooth, but that the weather was becoming unsettled. She began to experience puffs or slight squalls from the north-west. The sky during the day was covered with dense black clouds, and occasional showers fell, which became heavier and "smarter" as the day advanced. The winds were very variable, veering from S. through W. thence to S. E. and back to W. and N. W. The log of the Scottish Hill, which was about 180 miles to the west of the Mount Stuart, gives similar information. The winds were very light and variable, veering round the compass, the sky was heavily clouded, and the weather dull and gloomy.

Hence the various observations indicate the continuance and slight development of the conditions which, according to our experience of the meteorology of the Bay, precede the formation of cyclonic storms. On the other hand, they give no evidence of the existence at this time of a

cyclonic circulation in the Martaban Gulf. South-westerly winds were increasing in force over the south-east of the Bay, and were being continued much further north than is usual in the month of November. To the west of the Andamans, winds were exceedingly light and variable, and such as to show that the south-west winds advancing northwards were not being continued in that direction near the earth's surface. The clouding over of the sky, the commencement of showers increasing in intensity and accompanied with slight squalls, indicate clearly that ascensional movement on a large scale was commencing over that area, and giving rise to its usual result when it is partly fed and maintained by a moist current, namely, rainfall increasing in intensity, which, by a known law of rainfall, tends to become concentrated over a limited area.

*9th November.*—There are no new features of interest in the meteorology of the Indian land area. Pressure continued to give way in all parts of India. The decrease was greatest in Sind, Rajputana, and the Punjab. The area of barometric depression over the Indus valley was now very distinctly marked. It had as yet exercised no marked influence in the weather of Upper India. The winds were, however, drawing round in the Punjab and neighbouring districts, and indicated a feeble cyclonic air circulation over Upper India. The ascensional movement which necessarily accompanied it, had not given rise to the formation of cloud, except over the North-Western Himalayas.

Over the whole of Bengal and the North-Western and Central Provinces, the air motion was very slight, averaging only 1 to 2 miles per hour.

In Southern India the weather conditions were unchanged. Cloudy skies continued in the Madras Presidency, and a few occasional showers of no importance were received.

The observations at the coast stations of the Bay of Bengal present the same features as hitherto. The baric gradients were apparently normal in direction, but somewhat smaller than usual, and the differences of pressure comparatively small. The most important feature was the weakness of the north-easterly winds on the Coromandel coast. This is shown by the following statement :—

| Stations.          | Amount of wind<br>in miles per hour<br>since 10 A. M.<br>previous day. | Average daily<br>amount of wind<br>(miles per hour)<br>in November. |
|--------------------|--|---|
| Vizagapatam .....  | 2  | 2·5   |
| Masulipatam .....  | 2  | 6·0   |
| Madras .....       | 5  | 6·8   |
| Negapatam .....    | 3  | 5·6   |
| Trichinopoly ..... | 1  | 4·6   |
| Madura .....       | 3  | 4·1   |

The information respecting the weather in the Bay is as hitherto meagre.

The following are the observations taken at the land observatories in the neighbourhood of the cyclonic disturbance :—

| Stations.        | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind direction. |          | Velocity in miles per hour since 10 A. M. previous day. | Cloud amount at 10 A. M. | Rainfall at 10 A. M. preceding 24 hours. | Weather.       |
|------------------|---|-------------------------------------|-----------------|----------|---|--------------------------|--|----------------|
|                  |   |                                     | 10 A. M.        | 4 P. M.  |   |                          |  |                |
| Nancowry .....   | 29.897                                      | — .025                              | S. W.           | S. W.    | 8   | 9                        | 2.02                                     | Gloomy.        |
| Port Blair ..... | 29.894                                      | — .042                              | W.              | W. S. W. | 7   | 9                        | 0.17                                     |                |
| Diamond Island   | 29.900                                      | — .030                              | E. S. E.        | E. S. E. | 10  | 5                        | 1.41                                     | Fine.          |
| Chittagong ...   | 29.921                                      | — .032                              | E. N. E.        | N. N. W. | 1   | 2                        | ...                                      | Fine.          |
| Tounghoo .....   | 29.873?                                     | — .107?                             | N. W.           | N. W.    | ?   | 10                       | 1.10                                     | Thunder storm. |
| Bassein .....    | 29.924                                      | — .017                              | E. S. E.        | S. E.    | 5   | 10                       | 0.17                                     | Gloomy.        |
| Rangoon .....    | 29.942                                      | — .023                              | E. S. E.        | S. S. E. | 4   | 10                       | 0.69                                     | Showery        |
| Moulmein .....   | 29.898                                      | — .030                              | N. E.           | E. S. E. | 2   | 1                        | 0.71                                     | Showery        |
| Mergui .....     | 29.995?                                     | + .030?                             | S. S. E.        | S. S. E. | 2   | 10                       | ...                                      | Gloomy.        |

The Nancowry returns shew that a fall of .03" had occurred in the barometer. The winds were slightly stronger, but were only blowing with an average velocity of 8 miles per hour, the normal rate at that station in November. The sky was overcast, and rain continued to fall in moderate amounts. 2.02 inches were registered for the 24 hours preceding 10 A. M.

Heavy rain was apparently falling at this time to the north-east of the Nicobars and to the east of the Andamans. There is no direct evidence of this statement. The first indications, however, of cyclonic motion are presented by the Port Blair observations of this day. The barometer was falling at that station, the sky was, as on the 8th, densely clouded, and heavy rain began to fall in the afternoon and evening. The wind shifted round to west at 10 A. M. and to W. S. W. at 4 P. M. On the opposite coast of the Martaban Gulf, the sky was overcast, but little rain fell. In South Burmah, the weather was fine with passing clouds, which gave occasional showers. The sea was slight at Diamond Island. Hence the evidence is fairly complete that there was, as on the 8th, no definite cyclonic circulation, although there were slight indications of its commencement.

The shift of wind at Port Blair, and the occurrence of rainfall with squalls to the west of it, render it almost certain that the usual actions, which initiate the formation of an atmospheric whirl on a large scale, were now commencing. The meteorology of the 10th will show that the formation probably proceeded slowly during the afternoon and night of the 9th, but afterwards with increasing rapidity.



The meteorological information relating to the weather in the Bay of Bengal on the 9th, extracted from the logs of vessels, is tabulated below :—

| Vessel.          | Hour.   | Latitude.<br>N.                | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.   |          | REMARKS.   |
|------------------|---------|--------------------------------|------------------|---------------------------------------|----------|----------|--|
|                  |         |                                |                  |                                       | Dir.     | Force.   |  |
| Scottish Hill    | Noon    | 13° 1'                         | 89° 42'          | 29·920                                | N. W.    | 1        | Light airs and calms.  |
|                  | 4 P. M. |                                |                  |                                       | W.       | 0        | Very sultry, clouds in light masses.   |
|                  | 8 P. M. |                                |                  |                                       | N. N. W. | 0        | Sky dull lead colour.  |
|                  | Midnt.  |                                |                  | ·890                                  | W.       | 2        |  |
| Mount Stuart     | Noon    | 13° 8'                         | 92° 2'           | 29·875                                |          | 0        | Sky overcast with heavy clouds all round. Weather unsettled. There was a good deal of lightning in the sky this morning and towards midnight, mostly in the N. W. Midnight. Weather showery. |
|                  | 8 P. M. |                                |                  |                                       | N. E.    | 1 to 3   |  |
|                  | Midnt.  |                                |                  |                                       | E. S. E. | 1 to 2   |  |
| Kwang Tung       | 4 A. M. |                                |                  | 29·924                                | N. E.    | 5        |  |
|                  | 8 A. M. |                                |                  | ·911                                  | N. E.    | 5        | Current during the 24 hours, S. 12° E. 15 miles.   |
|                  | Noon    | 17° 37'                        | 90° 20'          | ·936                                  | N. E.    | 5        | Sea smooth.  |
|                  | 4 P. M. |                                |                  | ·883                                  | N. E.    | 5        |  |
|                  | 8 P. M. |                                |                  | ·856                                  | N.       | 5        |  |
|                  | Midnt.  |                                |                  | ·891                                  | N. E.    | 5        |  |
| Satara .....     | Noon    | Anchored at Gopaul-pore Roads. |                  | 29·950                                | E. by N. | 2        | Light breeze and fine clear weather.   |
|                  | 4 P. M. |                                |                  | ·840                                  | ...      | 1        | Light airs and fine.   |
|                  | 8 P. M. |                                |                  | ·880                                  | ...      | 1        |  |
|                  | Midnt.  |                                |                  | ·870                                  | N E by E | 3        | Gentle breeze and fine.  |
| Frank Staf-ford. | 4 A. M. |                                |                  |                                       | N.       | 2        |  |
|                  | 8 A. M. |                                |                  |                                       | ...      | 2        | Fine and smooth sea.   |
|                  | Noon    | 21° 03'                        | 90° 10'          | 29·935                                | ...      | 0        |  |
|                  | 4 P. M. |                                |                  |                                       | N. W.    | 2        |  |
| Parthenope       | Noon    | Near Sand heads.               |                  | 29·930                                | N.       | Moderate | A. M. Light breeze and clear. Noon. Moderate breeze and hazy.  |
| Breadalbane      | Noon    | Near Sand heads.               |                  | 29·935                                | N.       |          | Calms and light airs from north throughout.  |
|                  | 4 P. M. |                                |                  |                                       | N.       | 1        | Sea smooth and smart showers in the latter part of the day.  |
|                  | 8 P. M. |                                |                  |                                       | Calm.    | 0        |  |



The Parthenope and Breadalbane, near the Sand Heads, had light airs and calms during the day. The ship Frank Stafford (in Lat.  $21^{\circ} 3'$  N. Long.  $90^{\circ} 10'$  E.) experienced gentle northerly winds with fine weather and a smooth sea.

The S. S. Kwang Tung had advanced 200 miles to the N. W., and was at noon in Lat.  $17^{\circ} 37'$  N. and Long.  $90^{\circ} 20'$  E. She experienced steady north-east winds of moderate force (5) during the day. The ships Mount Stuart and Scottish Hill were proceeding very slowly up the Bay, and had only made about 50 miles during the 24 hours preceding noon. The former was in Lat.  $13^{\circ} 8'$  N. and Long.  $92^{\circ} 2'$  E., and experienced similar weather to that of the preceding day. The sea was smooth as hitherto. The sky was covered with dense clouds, and heavy showers fell, more especially in the afternoon. The Scottish Hill was in the same latitude, but 160 miles further to the west. She had calms during the greater part of the day. The weather was very sultry. The air was apparently almost saturated with moisture. The sky was covered with clouds, and had an ominous appearance suggestive of bad weather.

The observations of the 9th shew that no atmospheric whirl had been initiated as yet in the Gulf of Martaban. Several of the conditions necessary for the formation of a cyclonic disturbance were present. Winds were light and variable over a considerable portion of the Bay. A strong humid current was advancing over the south of the Bay into the Gulf of Martaban, and was giving moderately heavy rain in the neighbourhood of the Andamans and Nicobars. The rainfall had hitherto been too diffused to initiate a large cyclonic disturbance. It was, however, increasing in amount, and becoming more concentrated in character, the one additional condition now apparently required for the establishment of a large atmospheric whirl.

*10th November.*—During the previous 24 hours, a further barometric fall occurred throughout the greater part of India. The fall was not so general as on the 8th and 9th, and was much smaller in amount. Pressure was very considerably below the normal over the whole country. The distribution of pressure was generally similar to that which obtained on the morning of the 9th. The area of lowest pressure included the south-western districts of the Punjab and Rajputana, over which there was a distinctly marked cyclonic circulation of the air. In the south of the Punjab, cloud had formed to a considerable extent, whilst, in the north-western Himalayas, thunder-storms with rain had occurred over the lower ranges, and snow had fallen on the higher ranges.

In the North West Provinces, Bengal, the Central Provinces, Central India, Bombay, and the northern districts of Madras, the sky was, as it had been for some time, clear, and the weather fine and settled, but un-

usually dry for the season. The sky was clouded on the Madras coast, but rain had now ceased to fall, as is shewn by the data given in the table on p. 130. The winds on the Madras coast were approximately normal in direction, varying between N. and N. N. W., but were unusually weak.

Hence the effect of the deflexion of the south-west monsoon current from its usual course at this time, which had been previously indicated by the light winds experienced by the Mount Stuart and Scottish Hill to the west of the Andamans, had now extended across the centre of the Bay to the Coromandel coast, over the whole of which area light unsteady winds were blowing. Pressure was very uniform round the north and west coasts of the Bay, as is shown by the following :—

|                     |        |                   |        |
|---------------------|--------|-------------------|--------|
| Saugor Island ..... | 29.929 | Vizagapatam ..... | 29.957 |
| False Point .....   | 29.951 | Madras .....      | 29.960 |

The following table gives the observations at the land stations for the day —

| Stations.        | Barometer at 10 A.M. reduced to sea level. | Change since 10 A. M. previous day. | Wind direction. |          | Velocity in miles per hour since 10 A. M. previous day. | Cloud amount at 10 A. M. | Rainfall at 10 A. M. preceding 24 hours. | Weather.  |
|------------------|--|-------------------------------------|-----------------|----------|---|--------------------------|--|-----------|
|                  |  |                                     | 10 A. M.        | 4 P. M.  |   |                          |  |           |
| Nancowry .....   | 29.856                                     | — .041                              | S. W.           | S. W.    | 8   | 9                        | 1.16                                     | Showery.  |
| Port Blair ..... | 29.850                                     | — .044                              | N. N. W.        | W. N. W. | 7   | 8                        | 0.30                                     | Gloomy.   |
| Diamond Island   | 29.917                                     | + .017                              | E. S. E.        | E. S. E. | 12  | 10                       | 0.65                                     | Gloomy.   |
| Chittagong ...   | 29.915                                     | — .006                              | N.              | N. W.    | 1   | 6                        | ...                                      | Fine.     |
| Toungahoo .....  | 29.905?                                    | + .032?                             | N. W.           | N. W.    | ?   | 10                       | 0.22                                     | Gloomy.   |
| Bassein .....    | 29.917                                     | — .007                              | N. E.           | S. S. .  | 4   | 10                       | 0.18                                     | Overcast. |
| Rangoon .....    | 29.920                                     | — .022                              | N. E.           | E. S. E. | 4   | 8                        | 0.85                                     | Showery.  |
| Moulmein .....   | 29.871                                     | — .027                              | E. N. E.        | S. E.    | 2   | 8                        | ...                                      | Showery   |
| Mergui .....     | 29.868?                                    | — .127?                             | E. S. E.        | E.       | 1   | 10                       | 0.65                                     | Gloomy.   |

The preceding observations establish that a considerable fall of the barometer had taken place during the previous 24 hours. The fall amounted to .04" at Nancowry and Port Blair, .03" at Moulmein, and .02" at Rangoon, and was greatest at Port Blair. Westerly winds of the same average strength as on the 9th had prevailed during the

previous 24 hours at Nancowry. The sky was densely clouded and moderate rain was falling. 1.16 inches of rain were registered at 10 A. M. At Port Blair, the wind had shifted round to north-west, but was not as yet blowing strongly. Rain was falling, but the amount registered up to 10 A. M. of the 10th was small. In South Burmah, the sky had become overcast, and the weather gloomy and threatening, more especially at Diamond Island and Toungoo. Less rain, however, fell on the Burmah coast than had been received on the previous day. It thus again appears probable, if not certain, that the rainfall was becoming more concentrated over a smaller area than hitherto, a favourable, if not a necessary, condition, according to the condensation theory, for the development of an atmospheric whirl.

These observations also show that cyclonic circulation had been initiated, and was now established over the centre and north of the Gulf of Martaban, and the adjacent part of the Bay; and that the central depression or centre of disturbance, as determined by the fall of the barometer, the amount of rain, and the velocity of the wind, was nearest to Port Blair, and to the east of it.

Hence it is evident that, although the conditions for the formation of a whirl had been present for some days, it was only on the 10th that the meteorological observations at the nearest land stations gave clear indications of its existence.

The information contained in the meteorological abstracts from the logs of vessels is tabulated below:—

| Vessel.       | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable reduced barometer. | Winds.   |        | REMARKS.   |
|---------------|---------|-----------------|------------------|-----------------------------|----------|--------|--|
|               |         |                 |                  |                             | Dir.     | Force. |  |
| Scottish Hill | 4 A. M. |                 |                  |                             | N.       | 1      | Light airs and calms.  |
|               | 8 A. M. |                 |                  |                             | N. E.    | 1      | Winds very variable.   |
|               | Noon    | 13° 31'         | 89° 40'          | 29.910                      | N. W.    | 1      | Light airs and calms.  |
|               | 4 P. M. |                 |                  |                             | N. N. W. | 2      | Squally and dirty.   |
|               | 8 P. M. |                 |                  |                             | N. N. E. | 3      | Arched rain squalls.   |
|               | Midnt.  |                 |                  | .890                        | N. W.    | 3      |  |
| Mount Stuart  | 4 A. M. |                 |                  |                             | N. E.    | 1 to 0 | Sea moderate with light westerly swell.  |
|               | 8 A. M. |                 |                  |                             | ...      | 3 to 4 | Light fleecy clouds.   |
|               | Noon    | 13° 55'         | 91° 31'          | 29.865                      | ...      | ...    | Lightning in the N.W.  |
|               | 4 P. M. |                 |                  |                             | ...      | 4      | Towards the afternoon, weather began to be squally. At sunset, sharp squalls and squally-looking all round. Midnight. Showery. |
|               | 8 P. M. |                 |                  | .805                        | ...      | ...    |  |
|               | Midnt.  |                 |                  |                             | E. by N. | ...    |  |

| Vessel.              | Hour.   | Latitude.<br>N.        | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.   |        | REMARKS.   |
|----------------------|---------|------------------------|------------------|---------------------------------------|----------|--------|--|
|                      |         |                        |                  |                                       | Dir.     | Force. |  |
| Satara .....         | 4 A. M. |                        |                  | 29·870                                | N. N. E. | 5      | Fresh breeze and fine.   |
|                      | 8 A. M. |                        |                  | ·940                                  | E. N. E. | 4      | Moderate breeze & fine.  |
|                      | Noon    | 17° 56'                | 88° 45'          | ·890                                  | NE by E. | 5      | Fresh breeze and fine throughout. Current during previous 24 hours, north 4 miles. |
|                      | 4 P. M. |                        |                  | ·810                                  | N. E.    | 4      | Moderate breeze and fine.  |
|                      | 8 P. M. |                        |                  | ·860                                  | E. by S. | 2      | Light breeze and fine clear weather.   |
|                      | Midnt.  |                        |                  | ·860                                  | E. N. E. | 2      | Same wind and weather.   |
| Kwang Tung           | 4 A. M. |                        |                  | 29·942                                | N. E.    | 5      |  |
|                      | 8 A. M. |                        |                  | ·899                                  | N.       | 4      |  |
|                      | Noon    | 20° 00'                | 88° 49'          | ·920                                  | N.       | 3      | Current S. 32° E. 24 miles.  |
|                      | 4 P. M. |                        |                  | ·859                                  | N.       | 3      | Sea smooth.  |
|                      | 8 P. M. |                        |                  | ·904                                  | Calm.    |        |  |
|                      | Midnt.  |                        |                  | ·934                                  | Calm.    |        |  |
| Frank Staf-<br>ford. | 4 A. M. |                        |                  |                                       | N. N. W. | 2      |  |
|                      | Noon    | 21° 16'                | 89° 20'          | 29·915                                | ...      | 2      | Fine, and smooth sea.  |
|                      | Midnt.  |                        |                  |                                       | ...      | 2      | Lightning during the night.  |
| Chanda .....         | Noon    | Hughly River           |                  | 29·910                                | E. N. E. | 2      |  |
|                      | 4 P. M. |                        |                  | ·830                                  | E. N. E. | 4      |  |
|                      | 8 P. M. |                        |                  | ·870                                  | Calm.    | ...    |  |
|                      | Midnt.  |                        |                  | ·910                                  | E.       | 2      |  |
| Mahratta ...         | 4 P. M. | Passing Saugor Island  |                  | 29·820                                | E.       | 2      | Fine weather.  |
|                      | 8 P. M. |                        |                  | ·900                                  |          | 0      | Clear sky but slightly hazy.   |
|                      | Midnt.  |                        |                  | ·920                                  | N. N. E. | 2      |  |
| Parthenope           | Noon    |                        |                  | 29·915                                | N.       |        | A. M. Light breeze and hazy weather.   |
|                      | 4 P. M. | Passing Saugor Island. |                  |                                       | Calm.    |        | P. M. Wind unsteady with gusts and calms. Midnight. Wind north and light.          |



The observations given in the ships' logs, although not numerous, confirm the information of the land observations given above.

The Frank Stafford and Kwang Tung, north of Lat.  $20^{\circ}$  N. and near the Head of the Bay, met with light northerly winds or calms and a smooth sea. The Mount Stuart and Scottish Hill were passing very slowly up the Bay at this time. The former was in Lat.  $13^{\circ} 56'$  N. and Long  $91^{\circ} 31'$  E., and observed several of the evidences of cyclonic formation in its neighbourhood. The area of heavy rainfall, as already noticed, had contracted. This explains the fact mentioned in her log that in the morning there were only a few light clouds in the sky. The weather, however, rapidly changed during the day, and became squally in the afternoon. Sharp squalls were experienced at sunset. The barometer was also falling rather rapidly. Winds were from north, and increased in strength from 1 to 4 during the day, indicating the rapid increase of indraught. The Scottish Hill was 120 miles further to the west, and had winds ranging between N. E. and N. W. during the day. They were very light and variable during the earlier part of the day, but the weather became squally towards the evening, and arched rain squalls passed over the ship at 8 P. M. The Satara, which was passing from Gopalpore to Rangoon, was in Lat.  $17^{\circ} 56'$  N. and Long.  $88^{\circ} 45'$  E. at noon. The winds varied during the day between N. N. E. and E. N. E., but decreased in strength during the afternoon. She experienced light breezes and fine clear weather throughout the day. The Chanda and Marhatta left Saugor in the evening, and had fine weather and a clear sky.

Hence, except in the neighbourhood of the Andamans, weather was fine. A definite cyclonic circulation had been established to the east of the Andamans between 10 A. M. of the 9th and 10 A. M. of the 10th. The area of rainfall had for some time contracted, and the rainfall had intensified over the diminished area. Winds of indraught had hence been established, and were increasing in force. This proceeded slowly at first, but, during the evening of the 10th and morning of the 11th, it went on more rapidly, and there was a perfectly well-defined cyclonic circulation, or large atmospheric whirl, established in that part of the Bay on the morning of the 11th November.

*11th November.*—During the previous 24 hours the barometer had risen rapidly over Northern and Central India. The increase of pressure was due to the filling up of the depression in the Punjab and neighbouring districts. The rise of the barometer at Peshawar and Rawal Pindi was  $2''$ . The depression had given a large amount of rain over the Punjab, and stormy weather over the north-west Himalayas, on the higher parts of which much snow had fallen. Amongst the heaviest rain-

falls during the previous 24 hours were the following:—Simla 2·15 inches, Peshawar 1·22 inches, and Rawal Pindi 1·20 inches.

The sky was overcast, and the weather unusually cold, in Upper India. The winds over a large part of Northern India continued to indicate feeble cyclonic circulation about a centre in the north-eastern districts of Sind. Over the whole of Bombay (excluding Sind), Bengal, the Central Provinces, and Central India, the weather was fine, skies cloudless, and the winds blowing from the usual quarter.

Round the coast of the Bay, from Saugor Island to Madras, the differences of pressure were unusually small. The following statement gives the 10 A. M. reduced readings at the more important stations:—

|                     |        |
|---------------------|--------|
| Saugor Island ..... | 29·940 |
| False Point .....   | 29·955 |
| Vizagapatam .....   | 29·945 |
| Madras .....        | 29·948 |

The winds at the Bengal stations near the Head of the Bay blew from directions between north and north-east, the easterly component being probably due to the cyclonic circulation in the middle of the Bay. They were very light. On the Madras coast, the winds were not only more northerly than usual, but were unusually feeble. The data are given in the following table:—

| Stations.        | Amount of wind<br>in miles per<br>hour since 10<br>A. M. previous<br>day. | Daily average<br>amount of wind<br>(miles per hour)<br>of November. |
|------------------|---|---|
| Vizagapatam..... | 1   | 2·5   |
| Masulipatam..... | 3   | 6·0   |
| Madras .....     | 5   | 6·8   |
| Negapatam .....  | 2   | 5·6   |
| Salem .....      | 2   | 3·6   |
| Madura .....     | 2   | 4·1   |

Over the Coromandel coast, the weather was fine with passing clouds, and rain had entirely ceased.

The following table gives the observations taken at the recording stations in the neighbourhood of the disturbance :—

| Stations.        | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind direction. |          | Velocity in miles per hour since 10 A. M. previous day. | Cloud amount at 10 A. M. | Rainfall at 10 A. M. preceding 24 hours. | Weather.           |
|------------------|---|-------------------------------------|-----------------|----------|---|--------------------------|--|--------------------|
|                  |   |                                     | 10 A. M.        | 4 P. M.  |   |                          |  |                    |
| Nancowry .....   | 29·836                                      | —·020                               | S. W.           | S. W.    | 12  | 7                        | 2·90                                     | Fine.              |
| Port Blair ..... | 29·760                                      | —·090                               | W. N. W.        | W. S. W. | 8   | 9                        | 3·90                                     | Overcast and rain. |
| Diamond Island   | 29·848                                      | —·069                               | E. N. E.        | E. N. E. | 12  | 10                       | 1·12                                     |                    |
| Chittagong ...   | 29·918                                      | +·003                               | N. E.           | W. N. W. | 1   | 3                        |  | Fine.              |
| Toungoo .....    | 29·860                                      | —·045                               | N. W.           | N. W.    | ?   | 10                       |  | Gloomy.            |
| Bassein .....    | 29·861                                      | —·056                               | N. N. E.        | N. N. E. | 5   | 10                       | 1·24                                     | Overcast.          |
| Rangoon .....    | 29·913                                      | —·007                               | N. E.           | N. E.    | 5   | 9                        | 0·04                                     | Showery.           |
| Moulmein .....   | 29·855                                      | —·016                               | N.              | E. S. E. | 2   | 8                        | 0·03                                     | Fine.              |
| Mergui .....     | 29·884                                      | +·016                               | E. S. E.        | E.       | 3   | 10                       | 1·30                                     | Overcast.          |

These observations show that the barometer had fallen considerably at Port Blair, and to a less extent at Nancowry and Diamond Island. The cause of this is also evident from the observations. Heavy rain had fallen at Port Blair and the neighbourhood. Port Blair registered 3·9 inches at 10 A. M., Nancowry 2·90 inches, and Diamond Island 1·12 inches. The rainfall on the Burmese coast was smaller than on the previous day. Hence the evidence indicates that the rainfall was more concentrated than hitherto, and was falling mainly over an area near to and including Port Blair. This is confirmed by the fact that cyclonic circulation of the air was now fully established. Winds were S. W. at Nancowry, E. S. E. at Mergui, E. N. E. at Diamond Island, and W. N. W. at Port Blair. They were increasing in force rapidly, but were as yet of moderate strength. The wind directions indicate that the centre of the cyclonic circulation was to the east-north-east of Port Blair. It is not possible to infer its position with any approach to exactness from the observations, but we are probably not far from the truth in placing it in Lat. 13° 30' N. and Long. 94° 15' E.

As the vessels which have contributed meteorological data were all to the west and north of the Andamans, they only furnish information

of the weather in the outer portion of the north-west quadrant of the cyclonic circulation.

The following table gives the whole of the information contained in their logs respecting the weather in the Bay on the 11th :—

| Vessel.       | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.                 |          | REMARKS.   |
|---------------|---------|-----------------|------------------|---------------------------------------|------------------------|----------|--|
|               |         |                 |                  |                                       | Dir.                   | Force.   |  |
| Scottish Hill | 4 A. M. |                 |                  |                                       |                        |          | Dirty rain squalls.  |
|               | 8 A. M. |                 |                  |                                       | N. E.                  | 4        | No sea.  |
|               | Noon    | 14° 08'         | 90° 33'          | 29·850                                | to                     | 4        | Heavy rain squalls and hail.   |
|               | 4 P. M. |                 |                  |                                       | N. W.                  | 5        | Cloudy, gloomy sky.  |
|               | 8 P. M. |                 |                  |                                       | N. N. W.               | 2        | 6 P. M. Heavy swell from N. E.   |
|               | Midnt.  |                 |                  | ·870                                  | N.                     | 5        | Scud from N. E. and N. N. E.<br>Wind shifting in squalls.  |
| Mount Stuart  | 4 A. M. |                 |                  |                                       | E. N. E.               | 2 to 3   | A. M. Moderate in the first part of the day  |
|               | 8 A. M. |                 |                  |                                       | E. by N.               | ...      | Towards night, a heavy swell from E.   |
|               | Noon    | 15° 30'         | 91° 06'          | 29·820                                | NNE to E               | 3 to 5   | by N. Thick heavy rain most of the day.  |
|               | 4 P. M. |                 |                  | ·750                                  | N. E.                  | ...      | Overcast heavy sky all round, and dark gloomy weather.   |
|               | 8 P. M. |                 |                  | ·810                                  |                        |          | Bent storm sails at 2 P. M. and kept away south, as weather was looking very bad. Heavy swell from E. N. E. at midnight. |
|               | Midnt.  |                 |                  |                                       | N. by E to<br>N. by W. | Squally. |  |
| Byculla ..... | 4 A. M. |                 |                  | 29·880                                | N. E.                  | 7        | A. M. Moderate breeze and squally.   |
|               | 8 A. M. |                 |                  | ·890                                  | E. N. E.               |          | 8 A. M. Overcast and squally with heavy rain.  |
|               | Noon    | 16° 00'         | 91° 10'          | ·840                                  | ...                    |          | Noon. Moderate breeze and overcast, with threatening appearance and rising sea.  |
|               | 4 P. M. |                 |                  | ·770                                  | ...                    |          | 4 P. M. Strong breeze and overcast, with frequent hard squalls.  |
|               | 8 P. M. |                 |                  | ·770                                  | ...                    |          | 8 P. M. Strong freshening breeze, with hard squalls and rising sea.  |
|               | Midnt.  |                 |                  | ·740                                  | ...                    |          | Midnight. Moderate gale and heavy squalls.   |
|               |         |                 |                  |                                       |                        |          |  |



| Vessel.      | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.            |        | REMARKS.   |
|--------------|---------|-----------------|------------------|---------------------------------------|-------------------|--------|--|
|              |         |                 |                  |                                       | Dir.              | Force. |  |
| Satara ..... | 4 A. M. |                 |                  | 29·800                                | N. E.             | 4      | 4 A. M. Moderate breeze and overcast sky, with passing squalls of wind. 8 A. M. Fresh breeze, sky cloudy and overcast. Squally appearance. Black bank of clouds rising to the East. 10 A. M. A gale of wind from N. E. 11 A. M. Wind moderating. Noon. Strong head wind and mountainous sea. Shipping large quantities of water, vessel pitching and rolling. 4 P. M. Strong breeze and heavy sea, with severe squalls of wind, and incessant rain. 8 P. M. to midnight. Same weather continued. |
|              | 8 A. M. |                 |                  | ·850                                  | N. E.             | 5      |  |
|              | Noon    | 16° 35'         | 92° 09'          | ·800                                  | E. N. E.          | 6      |  |
|              | 4 P. M. |                 |                  | ·740                                  | E. N. E.          | 6      |  |
|              | 8 P. M. |                 |                  | ·800                                  | E.                | 6      |  |
|              | Midnt.  |                 |                  | ·780                                  | E. by N.          | 6      |  |
| Loanda ..... | Noon    | 16° 30'?        | 92° 0'?          |                                       | N. E.             | 4 to 5 | Weather overcast.  |
| Bancoora ... | 4 A. M. |                 |                  | 29·902                                | E.                | 2      | Moderate wind and fine.  |
|              | 8 A. M. |                 |                  | ·929                                  | N. E.             | 3      |  |
|              | Noon    | 17° 19'         | 85° 44'          | ·887                                  | N. E.             | 4      |  |
|              | 4 P. M. |                 |                  | ·838                                  | N. N. E.          | 4      |  |
|              | 8 P. M. |                 |                  | ·867                                  | N. E. by N.       | 4      |  |
|              | Midnt.  |                 |                  | ·840                                  | N. N. E.          | 4      |  |
| Chanda ..... | 4 A. M. |                 |                  | 29·830                                | N. E.             | 2      | Hazy.  |
|              | 8 A. M. |                 |                  | ·920                                  | N. N. E.          | 4      |  |
|              | Noon    | 18° 56'         | 90° 30'          | ·920                                  | N. N. E.          | 4      |  |
|              |         |                 |                  |                                       | N. E. to S. E.    | 2      | At short intervals, heavy squalls from S. E.   |
|              | 4 P. M. |                 |                  | ·750                                  | S. E.             | 2      |  |
|              | 8 P. M. |                 |                  | ·770                                  | Variable.         | 4      |  |
|              | Midnt.  |                 |                  | ·770                                  | S. E. to E. by S. | 5      | Heavy squalls from the eastward.   |

| Vessel.      | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.   |        | REMARKS.  |
|--------------|---------|-----------------|------------------|---------------------------------------|----------|--------|---|
|              |         |                 |                  |                                       | Dir.     | Force. |   |
| Asia .....   | Noon    | 18° 53'         | 84° 39'          |                                       | N. E.    |        | Moderate wind, clear weather.                       |
| Mahratta ... | 4 A. M. |                 |                  | 29·860                                | N. N. E. | 4      |   |
|              | 8 A. M. |                 |                  | ·920                                  | ...      | 4      | Fine weather, smooth sea, and clear sky throughout. |
|              | Noon    | 21° 16'         | 90° 35'          | ·940                                  | ...      | 4      |   |
|              | 4 P. M. |                 |                  | ·800                                  | N.       | 3      |   |
|              | 8 P. M. |                 |                  | ·870                                  | ...      | 3      |   |
|              | Midnt.  |                 |                  | ·900                                  | ...      | 2      |   |

The Satara, Byculla, Mount Stuart, and Scottish Hill were now in directions varying between N. N. W. and W. N. W. from the centre and at approximately the same distance, 250 miles. The Satara was in Lat. 16° 35' N. Long. 92° 9' E. by account at noon, and proceeding eastwards to Rangoon. Early in the morning, the weather was fine with moderate breezes. Occasional squalls of wind passed over the vessel. The weather became rapidly worse after 8 A. M. A heavy and dark bank of clouds appeared in the east, and at 10 A. M. a gale of wind blew from north-east. The sea rose very rapidly. During the afternoon and evening, the vessel experienced strong easterly winds with frequent heavy squalls, incessant rain, and a heavy sea. The Satara was not only approaching the centre, but was crossing its line of motion in front. Hence the very rapid change of weather which she experienced during the afternoon.

The Byculla was about 70 miles to the W. S. W. of the Satara at noon in Lat. 16' N. and Long. 91° 10' E. Her positions, as obtained by observation and dead reckoning, agree so closely as to show that there was no strong current in the northern and western quadrants of the cyclone, and hence that the position assigned to the Satara by account is probably approximately correct. The Byculla was advancing in almost the same track as the Satara, and gives a similar account of the weather. The morning began with moderate breezes and occasional squalls. The sky clouded over about 8 A. M., and heavy rain fell. The winds increased in force, and frequent hard squalls passed over the ship.

The Log of the ship Mount Stuart, which was in Lat.  $15^{\circ} 30'$  N. and Long.  $91^{\circ} 6'$  E. at noon, states that the sky was overcast, weather dark and gloomy, and so threatening at 2 p. m. that the Captain changed her course and kept away south. The Scottish Hill was 100 miles to the south-south-west in Lat.  $14^{\circ} 8'$  N. and Long.  $90^{\circ} 33'$  E. at noon. The sky was overcast, and frequent heavy rain squalls passed over the ship. A heavy swell from the north-east came up during the day. The weather over the north-east of the Bay is described in the logs of the Chanda, Bancoora, and Mahratta. The Bancoora, in Lat.  $17^{\circ} 19'$  N. and Long.  $85^{\circ} 44'$  E. at noon, had fine weather and moderate north-easterly winds of force varying from 2 to 4 during the day. The Chanda, in Lat.  $18^{\circ} 56'$  N. and Long.  $90^{\circ} 30'$  E. at noon, had fine weather with a hazy atmosphere, and light to moderate north-east winds. She was proceeding to Rangoon, and steaming directly towards the northern quadrant of the cyclone. Late in the evening, she began to experience squally weather and variable winds. Frequent heavy rain squalls came up from south-east and east after 8 p. m. The Mahratta proceeding from Chittagong to Calcutta, and the light vessels at the entrance to the Hooghly, had fine weather, clear skies, and a smooth sea throughout the whole day.

The meteorological data hence shew conclusively that, during the 24 hours preceding 10 a. m. of the 11th, a definite cyclonic circulation of considerable intensity had been established to the west of the Andamans, the centre of which at noon of the 11th was probably in Lat.  $13^{\circ} 30'$  N. and Long.  $94^{\circ} 15'$  E. Heavy rain was falling over and near the centre, winds increased considerably in force during the day, the sea rose rapidly, and gave rise to a heavy swell extending to a distance of three or four hundred miles from the centre. The very rapid changes which had been initiated by the cyclonic motion are indicated very clearly by the weather experienced by the Satara.

*12th November.*—The barometric changes of the preceding 24 hours were irregular. This was in part due to the continuance of unsettled weather in Upper India. The depression which had formed on the 9th and 10th was filling up, and its existence was chiefly shewn on the morning of the 12th by cyclonic circulation of the air in Sind, and the adjacent districts of Rajputana. A smaller depression had, however, formed in the south-eastern districts of the Punjab, the centre of which was at or near Lahore. This was shown by a slight fall of the barometer at Lahore and the neighbouring stations. The barometer had continued to rise rapidly over the greater part of the Punjab, Rajputana, and the Central Provinces, and over the whole of Central and Southern India. A rapid fall had occurred in Burmah, and a slight one in Bengal, due to the development and extension of the atmospheric whirl in the neighbourhood of the Andamans.

In Upper India, skies were more or less clouded in the area of the small depression, and rain fell during the day over nearly the whole of the Punjab, and the western districts of the North Western Provinces. In Bengal, the Central Provinces, Bombay, and Madras, skies were generally clear, weather fine, and winds light. Skies were overcast in Southern Burmah, and rain was generally falling.

Over the west coast of the Bay, pressure was remarkably uniform, the isobar of 29·95 being, in fact, almost identical with the coast line. The winds on the Coromandel coast were stronger than they were on the previous day, but were below their normal force. This is shown by the following statement :—

| Stations.         | Amount of wind<br>in miles per<br>hour since 10<br>A. M. previous<br>day. | Daily average<br>amount of wind<br>per hour. |
|-------------------|---|--|
| Vizagapatam ..... | 2   | 2·5  |
| Coconada .....    | 6   | 9·0  |
| Masulipatam ..... | 2   | 6·0  |
| Madras .....      | 5   | 6·8  |
| Negapatam .....   | 5   | 5·6  |
| Salem .....       | 2   | 3·6  |
| Madura .....      | 4   | 4·1  |

The following are the observations taken at the stations affected by the cyclonic depression :—

| Stations.        | Barometer at 10<br>A. M. reduced to<br>sea level. | Changes since 10<br>A. M. previous<br>day. | Wind direction. |          | Velocity in miles<br>per hour since<br>10 A. M. previous<br>day. | Cloud amount at<br>10 A. M. | Rainfall at 10 A. M.<br>preceding 24<br>hours. | Weather.                    |
|------------------|---|--|-----------------|----------|--|-----------------------------|--|-----------------------------|
|                  |   |  | 10 A. M.        | 4 P. M.  |  |                             |  |                             |
| Nancowry .....   | 29·884  | + ·048                                     | S. W.           | S. W.    | 7  | 7                           | 1·91   | Fine.                       |
| Port Blair ..... | 29·834  | + ·074                                     | W. S. W.        | W. S. W. | 18   | 8                           | 0·41   | Overcast                    |
| Diamond Island   | 29·659  | — ·189                                     | E. S. E.        | S. S. E. | 25   | 10                          | 4·58   | Severe<br>gale.             |
| Akyab .....      | 29·887  | ?  | N. N. E.        | E. N. E. | ?  | 10                          | ...  | Fine.                       |
| Chittagong ...   | 29·899  | — ·019                                     | Calm.           | N. N. W. | 1  | 6                           | ...  | Fine.                       |
| Toungoo .....    | 29·885  | + ·025                                     | N. W.           | N. W.    | ?  | 10                          | ...  | Gloomy<br>weather.          |
| Bassein .....    | 29·762  | — ·099                                     | E. N. E.        | E. S. E. | 12   | 10                          | 5·97   | Overcast                    |
| Rangoon .....    | 29·870  | — ·043                                     | E. N. E.        | S. E.    | 6  | 10                          | 0·84   | Showery                     |
| Moulmein .....   | 29·869  | + ·014                                     | S. E.           | S. E.    | 3  | 6                           | 0·04   | Clouds<br>low with<br>scud. |
| Mergui .....     | 29·936  | + ·052                                     | E. S. E.        | S. S. E. | 4  | 10                          | 0·50   | Overcast                    |



The following information relating to the meteorology of the Bay for the 12th is taken from the logs of the vessels named :—

| Vessel.       | Hour.    | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.               |        | REMARKS.  |
|---------------|----------|-----------------|------------------|---------------------------------------|----------------------|--------|---|
|               |          |                 |                  |                                       | Dir.                 | Force. |   |
| Mount Stuart  | 4 A. M.  |                 |                  | 29.700                                | N. N. W.             | 5      |   |
|               | Noon     | 14° 19'         | 91° 41'          | .750                                  | W. N. W.             | 5 to 6 | A number of small land birds at about sunset. The moon has had a large ring round it the last few nights.                     |
|               | 4 P. M.  |                 |                  |                                       | N. W.                | 5      |   |
|               | Midnt.   |                 |                  |                                       | N. W.                | 5      |   |
| Scottish Hill | 4 A. M.  |                 |                  | 29.770                                | N. N. W.             | 5      | 4 A. M. Cloudy and rain squalls. Heavy sea from N.E.  |
|               | 8 A. M.  |                 |                  | .790                                  | N. N. W.             | 4      | 8 A. M. Heavy rain squalls, sky thick and gloomy, heavy sea from N. N. E. Noon.   |
|               | Noon     | 14° 36'         | 92° 17'          | .720                                  | N. W. to<br>W. N. W. | 10     | Shift of wind to N. W. with heavy, fierce squalls. Sky one mass of heavy black clouds, and rain like a black wall to W. N. W. |
|               | 4 P. M.  |                 |                  | .630                                  | W. S. W.             | 10     | 2 P. M. Fierce squalls. Heavy bank of clouds to the N. W. and N.  |
|               | 5 P. M.  |                 |                  | .660                                  | W. S. W.             |        | 5 P. M. Weather clearer, and squalls lighter.   |
|               | Midnt.   |                 |                  | .720                                  | SW by W              | 8      | Heavy confused sea. Send in dark masses from N. W. Midnight.  |
|               |          |                 |                  |                                       |                      |        | Fresh squalls and heavy rain.   |
| Byculla ..... | 2 A. M.  |                 |                  | 29.730                                | E. N. E.             |        | 4 A. M. Freshening gale with very heavy squalls, blinding rain, and high head sea.  |
|               | 4 A. M.  |                 |                  | .660                                  | ...                  |        | Ship labouring heavily.   |
|               | 6 A. M.  |                 |                  | .570                                  | ...                  |        | 8 A. M. Strong gale with heavy squalls, and high N.E. sea.  |
|               | 8 A. M.  |                 |                  | .480                                  | N. E.                |        | Shipping water fore and aft.  |
|               | 10 A. M. |                 |                  | .480                                  | ...                  |        | Noon. Wind and sea increasing.  |
|               | Noon     | 16° 03'         | 92° 36'          | .410                                  | NE. by N.            |        | Heavy gale, with overcast sky, and continual heavy squalls.   |
|               | 2 P. M.  |                 |                  | .380                                  | N. N. E.             |        | Ship labouring heavily,   |
|               | 4 P. M.  |                 |                  | .380                                  | N. by E.             |        | and shipping heavy seas fore and aft.   |
|               | 6 P. M.  |                 |                  | .370                                  | N. by W.             |        |   |

| Vessel.                   | Hour.    | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.               |        | REMARKS.  |
|---------------------------|----------|-----------------|------------------|---------------------------------------|----------------------|--------|---|
|                           |          |                 |                  |                                       | Dir.                 | Force. |   |
| Bycnlla .....<br>(Contd.) | 8 P. M.  |                 |                  | 29·370                                | N. N. W.             |        | 8 P. M. Heavy gale<br>with terrific squalls<br>from the North.<br>Midnight. Weather<br>moderating.  |
|                           | 10 P. M. |                 |                  | ·390                                  | N. W. to             |        |   |
|                           | Midnt.   |                 |                  | ·400                                  | W. N. W.<br>West.    |        |   |
| Satara .....              | 4 A. M.  |                 |                  | 29·710                                | NE. by E.            |        | A. M. Strong gale from<br>N. E. with heavy sea,<br>accompanied with<br>heavy squalls of wind,<br>and incessant rain.<br>8 A. M. Hard gale,<br>violent squalls, heavy<br>rain, very thick wea-<br>ther. Noon. Wind<br>and sea continued<br>the same; heavy rain<br>squalls. 4 P. M. to<br>midnight. Strong<br>gale from E. by N.,<br>Same wind and wea-<br>ther.       |
|                           |          |                 |                  | ·660                                  | N. E.                | 9      |   |
|                           | 8 A. M.  |                 |                  | ·650                                  | ...                  | 9      |   |
|                           | Noon     | 16° 30'         | 93° 30'          | ·610                                  | E. by N.             | 9      |   |
|                           | 4 P. M.  |                 |                  | ·530                                  | ...                  | 9      |   |
|                           | 8 P. M.  |                 |                  | ·540                                  | ...                  | 9      |   |
|                           | Midnt.   |                 |                  | ·520                                  | E. S. E.<br>S. E.    | 9      |   |
| Chanda .....              | 4 A. M.  |                 |                  | 29·710                                | E. to NE.            |        | Morning. Heavysqualls<br>from E. N. E. Sea ris-<br>ing fast; S. E. swell<br>increasing rapidly.<br>Noon. Strong gale<br>with high cross sea.<br>Weather having all<br>the appearance of a<br>cyclone.<br>Afternoon. Fierce gale<br>and high sea, with<br>hard squalls and<br>heavy rain. Barome-<br>ter falling slowly.<br>Evening. Terrific<br>squalls and high sea. |
|                           | 8 A. M.  |                 |                  | ·730                                  | E. N. E. to<br>N. E. |        |   |
|                           | Noon     | 16° 31'         | 93° 09'          | ·640                                  | N. E.                |        |   |
|                           | 4 P. M.  |                 |                  | ·560                                  | N. E.                |        |   |
|                           | 8 P. M.  |                 |                  | ·610                                  | N. N. E.             |        |   |
|                           | 10 P. M. |                 |                  | ·490                                  |                      |        |   |
|                           | Midnt.   |                 |                  | ·560                                  | N. N. W.             |        |   |
| Bancoora ...              | 4 A. M.  |                 |                  | 29·798                                | N.                   | 4      | 6 A. M. Squally ap-<br>pearance to north-<br>ward.<br>2 P. M. Fresh breeze<br>and squally with light<br>rain. Heavy sea from<br>E. and E. N. E.   |
|                           | 8 A. M.  |                 |                  | ·849                                  | N.                   | 5      |   |
|                           | Noon     | 16° 40'         | 89° 11'          | ·805                                  | N.                   | 5      |   |
|                           | 4 P. M.  |                 |                  | ?                                     | N. N. W.             | 4      |   |
|                           | 8 P. M.  |                 |                  | ·818                                  | N. W.                | 4      |   |
|                           | Midnt.   |                 |                  | ·849                                  | N. N. W.             | 4      |   |

| Vessel.      | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.   |          | REMARKS.                           |
|--------------|---------|-----------------|------------------|---------------------------------------|----------|----------|------------------------------------|
|              |         |                 |                  |                                       | Dir.     | Force.   |                                    |
| Loanda ..... | Noon    | 16°45'?         | 91°46'?          | 29·700                                | E. N. E. | 6        | Heavy rain and sky overcast.       |
| Asia .....   | 4 A. M. |                 |                  |                                       | N. E.    | Moderate | Clear weather.                     |
|              | 8 A. M. |                 |                  |                                       | N. E.    | Fresh.   |                                    |
|              | Noon    | 17° 42'         | 87° 42'          |                                       | N. E.    | „        | Cloudy and confused swell.         |
|              | 4 P. M. |                 |                  |                                       | N. E.    | „        | Cloudy and heavy S.E. swell.       |
|              | 8 P. M. |                 |                  |                                       | N. E.    |          | Cloudy and heavy S.E. swell.       |
|              | Midnt.  |                 |                  |                                       | N. E.    | Strong.  | Overcast and heavy easterly swell. |

The observations at the land observatories indicate that the depression was to the north of the Andamans on the morning of the 12th. The centre had thus moved in a north-north-west direction since noon of the 11th. The barometer had risen considerably at Port Blair and Nancowry, and on the east coast of the Martaban Gulf. Strong winds continued at Nancowry and Port Blair, more especially at the latter station. The sky was cloudy at Nancowry, and was still very dark and gloomy at Port Blair. Moderate rain had fallen during the preceding 24 hours at these stations.

A very considerable fall of the barometer had occurred in South West Burmah, more especially at Diamond Island and at Bassein. The winds were unusually strong at Diamond Island. The observer at that station reported a severe gale at 10 A. M. Very heavy rain was also falling in South Burmah. Diamond Island registered 4·58 inches at 10 A. M., and Bassein, 5·97 inches. On the Arakan coast, the weather at 10 A. M. was fine with passing clouds, and light N. N. E. winds.

The position of the centre can only be roughly approximated from the land observations. It was evidently to the W. S. W. of Diamond Island and at no great distance. The information extracted from the ships' logs enables us to determine it with approximate accuracy. An examination of the positions of the vessels, as determined by observation and dead reckoning on the 12th and 13th, indicates, that the positions assigned to all the vessels, except the Satara, at noon of the 12th, may be accepted as approximately true. There appears to have been very little current in the western and

northern quadrants of the cyclonic area. The only marked current at this time in the Bay was in the eastern quadrant of the storm area, where the winds were strongest. This current was continued northwards along the west coast of Burmah. The Satara, which was nearest the coast, experienced a very strong northerly current, which carried her 171 miles to the northward and westward (N.  $13^{\circ}$  W.) between noon of the 11th and noon of the 14th. Her probable position at noon of the 12th, so far as can be determined from the wind direction and height of her barometer, was in Lat.  $16^{\circ} 30'$  N. and Long.  $93^{\circ} 30'$  E.

The Byculla, Satara, Loanda, and Chanda were all in the northern quadrant. The Byculla was nearest the centre, which apparently passed a short distance to the east of that steamer, late in the evening (about 8 P. M.) Early in the morning, she had a gale with very heavy squalls, blinding rain, and a high sea. The weather grew worse as she advanced southwards. At noon, she experienced a heavy gale with continual heavy squalls. The weather was at its worst about 8 P. M., when a heavy gale was blowing with terrific squalls. Her barometer (corrected) stood at that hour at 29.37, the lowest reading taken during the storm. The weather began to moderate at midnight, when she had westerly winds, and the storm was passing to the northward.

The Chanda also passed to the westward of the storm. She was at least 150 miles from the centre early in the morning of the 12th. At that time, heavy squalls from the E. N. E. passed over the vessel, and a swell came up from the south-east which increased rapidly. At noon, she had a fierce gale with hard squalls, and heavy rain. The barometer fell slowly, and the Captain at 4 P. M. judiciously changed the course of the vessel to the south-west, and thus kept clear of the storm centre. At 8 P. M., the squalls were terrific in force, and the sea very high. The barometer was at its lowest at 10 P. M., when the corrected reading was 29.49. The wind at that hour was hauling from N. N. E. to N. N. W. Shortly afterwards, the weather began to moderate.

The Satara was to the north of the centre during the day, and crossed from the western to the eastern quadrant. She, consequently, not only experienced the full force of the hurricane, but was carried a considerable distance to the northward by the current, and thus involved in it for a much longer time than either of the preceding vessels. Early in the morning, she had a strong gale from the N. E. with heavy squalls, incessant rain, and a high sea. She continued to experience similar weather during the day. The wind, which was from N. E. at 4 A. M., shifted to E. by N. at noon, and to S. E. at midnight. She was, judging from the unusually small rise of her barometer between 4 P. M. and 8 P. M., probably nearest to the centre between 8 P. M. and midnight. Her low-



est reading is not given, but when corrected, it probably slightly exceeded 29·5. She was about the same distance as the Chanda from the centre. The Mount Stuart and Scottish Hill were in the south-west quadrant, but at considerable distances from the centre. The former, which was in Lat.  $14^{\circ} 19'$  N. and Long.  $91^{\circ} 41'$  E. at noon, had winds of force 5 to 6 during the day. The Scottish Hill was nearer to the centre. During the morning, she had cloudy weather with rain squalls, and a heavy sea. Occasional shifts of wind occurred in heavy squalls, which passed over the vessel from the N. W. She was just on the margin of the storm area. The force of the wind varied from 4 to 5. The Captain describes the appearance of the cyclone area crossing to the N. W. in front of his ship as a mass of heavy black cloud and rain. During the remainder of the afternoon, fierce squalls passed over the vessel. The wind was of force 10, and hauled to W. S. W. at 4 P. M. The weather moderated a little afterwards, but she continued to have fresh squalls, heavy rain, and a high confused sea, during the remainder of the night.

The Asia was about 400 miles to the W. N. W. in Lat.  $17^{\circ} 42'$  and Long.  $87^{\circ} 42'$  E. at noon. She had fresh to strong N. E. winds during the day, and a heavy swell from the S. E. The Bancoora was 260 miles to the W. N. W. in Lat.  $16^{\circ} 40'$  N. and Long.  $89^{\circ} 11'$  E. She had northerly winds of force 5 until noon, and N. N. W. winds of force 4 during the remainder of the day. The weather had a squally appearance in the morning. As she advanced eastward, a heavy swell set in from the E. and E. N. E., which increased during the day. The logs of the Bhandara and of the light vessels near the mouth of the Hooghly show that light northerly winds were blowing at the Head of the Bay, and that the weather was fine, sky clear, and sea smooth.

A comparison of the position of the vessels at noon with respect to the storm indicates that the centre was approximately in Lat.  $15^{\circ} 30'$  N. and Long.  $93^{\circ}$  E. at noon.

On this supposition, the following were the distances and bearings of the vessels from the storm centre at noon:—

|                      | Bearing of<br>centre of<br>storm. | Distance of<br>centre of<br>storm. | Barometer<br>at noon. |
|----------------------|-----------------------------------|------------------------------------|-----------------------|
| Diamond Island ..... | E. N. E.                          | 90                                 | 29·64                 |
| Byculla .....        | N. N. W.                          | 45                                 | 29·41                 |
| Chanda .....         | N.                                | 75                                 | 29·64                 |
| Satara .....         | N. E.                             | 75                                 | 29·61                 |
| Scottish Hill .....  | S. W.                             | 85                                 | 29·72                 |
| Mount Stuart .....   | S. W.                             | 120                                | 29·75                 |
| Bancoora .....       | W. N. W.                          | 260                                | 29·81                 |
| Asia .....           | W. N. W.                          | 400                                | ?                     |

13th November.—The chief feature in the meteorology of India on the 13th was the cyclonic disturbance off the Burmese coast. A rapid rise of the barometer during the preceding 24 hours over the Punjab and Sind, completely obliterated the barometric depression in that area. Pressure was highest over the Indus valley, where it slightly exceeded 30·15". The barometer had also risen in the Central Provinces, Bombay, and Madras, but had decreased in Bengal and Arakan. Hence pressure diminished from west to east, and was lowest at Diamond Island, where it was 29·826".

The large depression off the Burmese coast was very distinctly marked. Winds were blowing a southerly gale in the Gulf of Martaban. They were easterly at Akyab, northerly in Bengal and on the Ganjam and Madras coasts, thus establishing general cyclonic circulation over the Bay. Elsewhere the winds were generally from the eastward, except in the Indus valley, where they were northerly.

The sky was dull and cloudy in the Punjab, and moderate rain had fallen during the previous 24 hours. The sky, however, rapidly cleared during the day, and was almost free of cloud by 4 P. M. Over the remainder of the Indian land area, excepting Burmah, the sky was clear and the weather fine. The following table gives the more important meteorological observations taken at the land stations:—

| Stations.        | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind direction. |          | Velocity in miles per hour since 10 A. M. previous day. | Cloud amount at 10 A. M. | Rainfall at 10 A. M. preceding 24 hours. | Weather.             |
|------------------|---|-------------------------------------|-----------------|----------|---|--------------------------|--|----------------------|
|                  |   |                                     | 10 A. M.        | 4 P. M.  |   |                          |  |                      |
| Nancowry .....   | 29·940                                      | +·056                               | S. W.           | S. W.    | 3   | 7                        | 0·83                                     | Fine.                |
| Port Blair ..... | 29·896                                      | +·062                               | W. S. W.        | W. S. W. | 10  | 5                        | 0·15                                     | Fine.                |
| Diamond Island   | 29·826                                      | +·167                               | S.              | S.       | 29  | 10                       | 1·47                                     | Severe gale.         |
| Akyab .....      | 29·863                                      | —·024                               | E. N. E.        | N. N. E. | 5   | 10                       | 0·59                                     | Showery.             |
| Chittagong ...   | 29·855                                      | —·044                               | N.              | Calm.    | 1   | 9                        | ...                                      | Sultry.              |
| Toungahoo .....  | 29·881                                      | —·004                               | N. W.           | N. W.    | ?   | 10                       | 0·42                                     | Threatening weather. |
| Bassein .....    | 29·830                                      | +·068                               | E. S. E.        | S. S. E. | 18  | 10                       | 5·90                                     | Overcast.            |
| Rangoon .....    | 29·887                                      | +·017                               | E. S. E.        | S. S. E. | 9   | 8                        | 2·42                                     | Constant rain.       |
| Moulmein .....   | 29·902                                      | +·033                               | S. S. E.        | S. S. E. | 3   | 3                        | 1·11                                     | Constant rain.       |
| Mergui .....     | 29·943                                      | +·007                               | S. E.           | Calm.    | 2   | 5                        | 0·30                                     |                      |

The information extracted from the logs of vessels affected by cyclonic disturbance off the Burmese coast is given in the ensuing statement:—

| Vessel.       | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable reduced barometer. | Winds.    |           | REMARKS.   |
|---------------|---------|-----------------|------------------|-----------------------------|-----------|-----------|--|
|               |         |                 |                  |                             | Dir.      | Force.    |  |
| Shazada.....  | 8 A. M. | 13° 14'         | 94° 00'          | 29·836                      | S. by E.  | Strong.   |  |
|               | Noon    | 13° 51'         | 93° 57'          |                             |           |           | Cloudy and overcast.   |
|               | 4 P. M. |                 |                  | ·714                        | S.        |           |  |
| Mount Stuart  | 4 A. M. |                 |                  |                             | N. W.     | 5         | Sea heavy from N. E. by N. It was more northerly towards noon. 2 P. M. Showery.  |
|               | 8 A. M. |                 |                  | 29·870                      | ...       | 5         | 4 P. M. Heavy detached clouds. 5 P. M. Dull heavy sky, with bright pink colour at sunset.                                      |
|               | Noon    | 14° 47'         | 91° 20'          |                             | W. N. W.  | 5         |  |
|               | 4 P. M. |                 |                  | ·740                        | ...       | 5 to 6    |  |
|               | 8 P. M. |                 |                  |                             | ...       | 5         |  |
|               | Midnt.  |                 |                  | ·800                        | vble.to W | 5         |  |
| Asia .....    | 4 A. M. |                 |                  |                             | N. E.     | Moderate. | Cloudy, heavy easterly swell, and squally.   |
|               | 8 A. M. |                 |                  |                             | N.        | Fresh.    | Overcast and heavy N. E. swell.  |
|               | Noon    | 15° 54'         | 90° 58'          |                             | ...       | ...       | Squally, overcast, heavy N. E. swell.  |
|               | 4 P. M. |                 |                  |                             | N. W.     | Moderate. | Overcast, N. E. swell going down.  |
|               | 8 P. M. |                 |                  |                             | W.        | ...       | Moderate breeze and overcast. Swell gone down.   |
|               | Midnt.  |                 |                  |                             | SW by W   | Steady.   | Moderate breeze and cloudy.  |
| Loanda .....  | Noon    | 16° 16'         | 92° 54'          | 29·500                      | N. E.     | 10        | Gale increasing.   |
|               | Midnt.  |                 |                  |                             |           |           | A hurricane.   |
| Scottish Hill | 8 A. M. |                 |                  | 29·750                      |           |           | Noon. Heavy rain squalls.  |
|               | Noon    | 15° 56'         | 92° 10'          | ·720                        | W. by S.  | 9         | 6 P. M. Scud flying fast from N. W. Severe squalls and heavy sea. 10 P. M. Weather clearer, sea lighter, squalls less violent. |
|               | 4 P. M. |                 |                  | ·700                        |           |           |  |
|               | 6 P. M. |                 |                  | ·680                        |           |           |  |
|               | 8 P. M. |                 |                  |                             | W. by S.  | 10        |  |
|               | Midnt.  |                 |                  | ·790                        |           |           |  |

| Vessel.       | Hour.    | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.              |        | REMARKS.   |
|---------------|----------|-----------------|------------------|---------------------------------------|---------------------|--------|--|
|               |          |                 |                  |                                       | Dir.                | Force. |  |
| Chanda .....  | 4 A. M.  |                 |                  | 29.610                                | NNW. to<br>W. N. W. |        | Wind and sea going<br>down. At short inter-<br>vals, terrific squalls at-<br>tended by heavy rain.<br>Strong wind and heavy<br>rain squalls.<br>Strong breeze and<br>cloudy. Occasional<br>heavy squalls.  |
|               | 8 A. M.  | 16° 02'         | 93° 11'          | .650                                  | WNW. to<br>S. W.    |        |  |
|               | Noon     |                 |                  | .670                                  | S. S. W.            |        |  |
|               | 4 P. M.  |                 |                  | .690                                  | S. S. W.            |        |  |
|               | 8 P. M.  |                 |                  | .790                                  | S. E.               |        |  |
|               | Midnt.   |                 |                  | .770                                  | SE. by S.           |        | Strong increasing<br>breeze, and cloudy<br>weather.  |
| Byculla ..... | 2 A. M.  |                 |                  | 29.440                                | W.                  |        | Heavy gale with dark<br>overcast sky. Wind<br>veered to S. W., in-<br>creased and blew with<br>great violence in<br>terrific squalls with<br>rain. High confused<br>sea.<br>8 A. M. Heavy gale<br>with terrific squalls<br>from S. W. to S. S. W.<br>High confused sea.<br>Shipping heavy water<br>fore and aft. 11 A. M.<br>Weather moderating,<br>but sea very confused.<br>Noon. Wind and sea<br>moderating. Squalls<br>less frequent and not<br>so hard.<br>8 P. M. Strong breeze<br>and overcast, with<br>sharp squalls and<br>heavy rain, high sea<br>still running. Mid-<br>night. Fresh breeze<br>with passing squalls.<br>Sea going down. |
|               | 4 A. M.  |                 |                  | .450                                  | S. W.               |        |  |
|               | 6 A. M.  |                 |                  | .460                                  | ...                 |        |  |
|               | 8 A. M.  |                 |                  | .510                                  | S. S. W.            |        |  |
|               | 10 A. M. |                 |                  | .520                                  | ...                 |        |  |
|               | Noon     | 16° 10'         | 93° 11'          | .560                                  | ...                 |        |  |
|               | 2 P. M.  |                 |                  | .580                                  | S. W.               |        |  |
|               | 4 P. M.  |                 |                  | .660                                  | ...                 |        |  |
|               | 6 P. M.  |                 |                  | .720                                  | ...                 |        |  |
|               | 8 P. M.  |                 |                  | .780                                  | ...                 |        |  |
|               | 10 P. M. |                 |                  | .810                                  | ...                 |        |  |
|               | Midnt.   |                 |                  | .830                                  | ...                 |        |  |
| Satara .....  | 4 A. M.  |                 |                  | 29.520                                | S. E.               | 8      | 4 A. M. Fresh gale, vio-<br>lent squalls of wind<br>and rain, heavy head<br>sea. 8 A. M. Strong<br>gale, violent squalls,<br>heavy rain. 10-4.5 A. M.<br>Wind shifted to S. by<br>E. Noon. Strong gale   |
|               | 8 A. M.  |                 |                  | .630                                  | ...                 | 9      |  |
|               | Noon     | 16° 20'         | 93° 30'          | .680                                  | S. E.               | 9      |  |
|               | 4 P. M.  |                 |                  | .670                                  | S. E.               | 8      |  |



| Vessel.                  | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.               |        | Remarks.  |
|--------------------------|---------|-----------------|------------------|---------------------------------------|----------------------|--------|---|
|                          |         |                 |                  |                                       | Dir.                 | Force. |   |
| Satara .....<br>(Contd.) | 8 P. M. |                 |                  | ·730                                  | ...                  | 8      | from S. E. Violent squalls of wind and rain. 4 P. M. Fresh gale, violent squalls of wind and rain. Sea moderating. Water had a greenish tint. 6-30 P. M. Fresh gale, thick weather, with violent squalls.   |
|                          | Midnt.  |                 |                  | ·750                                  | S by W to<br>S. E.   | 8      |   |
| Bancoora ...             | 4 A. M. |                 |                  | 29·828                                | N. W.                | 7      | 6-15 A. M. Tremendous heavy sea from N. E. 10 A. M. Lulls and very heavy squalls and rain. 7 P. M. Clearing somewhat, wind and sea moderating, vessel at times rolling fearfully.   |
|                          | 8 A. M. |                 |                  |                                       | W. N. W.             | 7      |   |
|                          | Noon    | 16° 31'         | 91° 55'          | ·770                                  | W. N. W.             | 6      |   |
|                          | 4 P. M. |                 |                  |                                       | West                 | 7      |   |
|                          | 8 P. M. |                 |                  |                                       | W. S. W.             | 4      |   |
|                          | Midnt.  |                 |                  | 30·049                                | W.                   | 3      |   |
| Mahratta ...             | Noon    | 22° 00'         | 91° 44'          | 29·910                                | S. W. to<br>S. E.    | 1      | 4 P. M. Slight swell from S. E. To eastwards, dense heavy clouds; to westwards, sky clear near the horizon; to northwards, light fleecy looking clouds, apparently motionless. Midnight. Sky completely overcast, with occasional rain and heavy swell. |
|                          | 4 P. M. |                 |                  | ·760                                  | E.                   | 2      |   |
|                          | 8 P. M. |                 |                  | ·780                                  | N. E.                | 3      |   |
|                          | Midnt.  |                 |                  | ·780                                  | E. N. E. to<br>N. E. | 5      |   |

The observations taken at the land stations show that the barometer had risen rapidly at Diamond Island, moderately at Bassein, Port Blair, and Nancowry, and very slightly at Mergui and Rangoon. It was falling slowly at Akyab and Chittagong, in front of the storm area.

Winds were much lighter at Nancowry and Port Blair, but were unaltered in direction, and continued to give moderate rain. They had veered to S. S. E. in Burmah, except at Diamond Island, where they were from the south. A severe gale of wind had prevailed at that station during the previous 24 hours, but was beginning to moderate. Heavy rain had been brought up by the southerly winds into South Burmah. Bassein received 5·9 inches, Rangoon 2·4, and Diamond Island 1·47 during the previous 24 hours.

The land observations are not sufficient to enable the position of the centre of the storm at this time to be inferred. The slight shift of wind at Diamond Island, the considerable rise of the barometer at that station, and the very small fall at Akyab, indicate that the storm was being largely influenced and retarded by the action of the Burmese and Arakan hills. The southerly winds in the easterly quadrant, instead of passing mainly over a water surface, were now blowing partly over South Burmah. The friction between the winds and the earth's surface, and the action of the hills in breaking up and disintegrating the rotatory or vorticoise motion of the air, evidently account for the change which was taking place, and which is more clearly shown by the ships' observations.

The Satara was in the north-east quadrant. Her position at noon was probably about Lat.  $16^{\circ} 20'$  N. and Long.  $94^{\circ}$  E. She was between the storm centre and the Burmese coast, and received the full weight of the southerly winds during the day. She had strong gales with violent squalls and heavy rain during the whole day, and the weather only began to moderate about 8 P. M., after which she had a fresh gale with thick weather and heavy squalls.

The position of the Loanda is slightly doubtful. She was almost in front of the cyclonic centre, probably a few miles only to the west. She had north-easterly winds of force 10 at midday. The storm increased, and at midnight was blowing a hurricane. Her barometer at midday (corrected) was 29·5.

The Byculla was in the south-east quadrant. She had crossed the path of the centre on the previous evening at about 11 P. M., and steamed away to the east during the day. Early in the morning, she was near the centre, and received the full weight of the south-westerly winds. The wind veered to south-west shortly after midnight, and blew with great violence; terrific squalls of wind and rain passing over the ship at intervals. At 8 A. M., the wind blew a heavy gale with terrific squalls from S. S. W. and S. W., bringing up a high confused sea. Weather began to moderate after 11 A. M., and in the afternoon, when the vessel was probably 200 miles away from the storm centre, she experienced fresh breezes with passing squalls. The barometer rose rapidly and continuously during the day from 29·44 at 2 A. M. to 29·83 at midnight.

The Chanda and Bancoora were passing early in the morning through the south-west and south quadrants of the depression. The Chanda experienced terrific squalls with heavy rain. The winds commenced at W. N. W., and hauled round to S. W. at 8 A. M. As she advanced south-eastwards during the afternoon, the weather improved, and wind shifted round to S. E., when strong breezes with occasional squalls and cloudy weather prevailed.

The Bancoora was further to the westward, and hence did not encounter such strong winds as the Chanda. During the day, the winds gradually shifted from north-west to west, and were of average strength 7. Very heavy squalls of wind and rain passed over the vessel, and a tremendous heavy sea came up from north-east early in the morning. As the storm centre passed to the northwards, and the vessel proceeded eastwards, the wind and sea moderated.

The remaining vessels were at greater distances away. The Scottish Hill to the W. S. W. of the centre (in Lat.  $15^{\circ} 56'$  N. and Long.  $92^{\circ} 10'$  E.) had very heavy rain squalls (force 9 to 10) during the day. The weather began to clear at about 10 P. M.

The Asia, in Lat.  $15^{\circ} 54'$  N. and Long.  $90^{\circ} 58'$  E. at noon, was proceeding south-eastward to Port Blair, and passed through the outer part of the south-westerly quadrant. She had squally overcast weather with a heavy N. E. swell during the day. At midnight, she had steady, moderate S. W. breezes with cloudy weather. The Mount Stuart was in the west and south-west quadrants, and experienced moderate winds of force 5, with occasional squalls.

The Mahratta, between Chittagong and Akyab, had light variable winds, and fine weather, during the early part of the day. The sky clouded over and was overcast at night, when rain began to fall, and a heavy swell to come up. The Bhundara, off Gopaulpore, had light airs or calms, and a clear sky.

Assuming the position for the storm centre at noon to have been in Lat.  $16^{\circ} 10'$  N. and Long.  $93^{\circ}$  E., the following table gives its position with respect to the vessels near it:—

| Names of Vessels.   | Position.        |                  | Direction of storm centre from vessel. | Distance of storm centre from vessel. | Barometer at Noon. |
|---------------------|------------------|------------------|--|---------------------------------------|--------------------|
|                     | Longitude. N.    | Latitude. E.     |  |                                       |                    |
| Loanda .....        | $16^{\circ} 16'$ | $92^{\circ} 54'$ | N. N. W.                               | 9                                     | 29.50 ?            |
| Chanda .....        | $16^{\circ} 02'$ | $93^{\circ} 11'$ | E.                                     | 15                                    | 29.69 ?            |
| Byculla .....       | $16^{\circ} 10'$ | $93^{\circ} 11'$ | E.                                     | 12                                    | 29.56              |
| Satara .....        | $16^{\circ} 20'$ | $93^{\circ} 30'$ | E. N. E.                               | 35                                    | 29.68              |
| Scottish Hill ..... | $15^{\circ} 56'$ | $92^{\circ} 10'$ | W.                                     | 56                                    | 29.72              |
| Bancoora .....      | $16^{\circ} 31'$ | $91^{\circ} 55'$ | W.                                     | 74                                    | 29.77              |
| Mount Stuart .....  | $14^{\circ} 47'$ | $91^{\circ} 20'$ | S. S. W.                               | 140                                   | 29.85              |
| Asia .....          | $15^{\circ} 54'$ | $90^{\circ} 58'$ | W.                                     | 130                                   | 29.85              |
| Mahratta .....      | $21^{\circ} 59'$ | $91^{\circ} 44'$ | N. N. W.                               | 400                                   | 29.91              |
| Bhundara .....      | Off Gopaulpore.  |                  | W.                                     | ...                                   | 29.89              |



14th November.—The only feature of importance in the meteorology of India was the depression off the Arakan and Burmese coasts. Pressure was again giving way quickly over the Punjab, and to a less extent in all other parts of the country, except at a few stations in Bombay, South Madras, and in Arakan. The highest pressure (30·1) was over Sind, and the lowest (29·69) in Arakan at Akyab. Gradients were not steep, except in and near the cyclonic disturbance. The storm centre in the Bay was approaching Akyab at 10 A. M. The weather was overcast with heavy rain in Burmah and Arakan. A considerable increase of cloud had taken place in Lower Bengal. The sky had cleared in the Punjab and North-west Himalaya, and weather was fine over the whole of India, except in the immediate neighbourhood of the cyclonic disturbance. The winds were more northerly than usual in Northern India. In Bengal and on the Madras coast, winds were blowing chiefly from the north west. They were, however, as during the previous week, light in the neighbourhood of the Madras coast.

The following tables give the observations relating to the weather of the 14th taken at the land stations in the neighbourhood of the cyclonic disturbance, and the meteorological information extracted from the logs of vessels :—

| Stations.        | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Wind direction. |          | Velocity in miles per hour since 10 A. M. previous day. | Cloud amount at 10 A. M. | Rainfall at 10 A. M. preceding 24 hours. | Weather.   |
|------------------|---|-------------------------------------|-----------------|----------|---|--------------------------|--|------------|
|                  |   |                                     | 10 A. M.        | 4 P. M.  |   |                          |  |            |
| Nancowry .....   | 29·921                                      | —·019                               | S. W.           | S. W.    | 2   | 8                        | 0·63                                     | Cloudy.    |
| Port Blair ..... | 29·924                                      | +·028                               | W. N. W.        | S. S. E. | 6   | 6                        | 0·61                                     | Cloudy.    |
| Diamond Island   | 29·898                                      | +·072                               | S.              | S.       | 17  | 7                        | 0·64                                     |            |
| Akyab .....      | 29·692                                      | —·171                               | N.              | W.       | 8   | 10                       | 2·44                                     | Raining.   |
| Chittagong ...   | 29·772                                      | —·083                               | N. W.           | W.       | 1   | 8                        | ...                                      | Gloomy.    |
| Tòungoo .....    | 29·866                                      | —·015                               | N. W.           | S. W.    | ?   | 10                       | 0·15                                     | Showery.   |
| Bassein .....    | 29·922                                      | +·092                               | W. S. W.        | S.       | 14  | 10                       | 1·42                                     | Overcast.  |
| Rangoon .....    | 29·921                                      | +·034                               | S.              | S. S. W. | 8   | 10                       | 0·83                                     | Drizzling. |
| Moulmein .....   | 29·913                                      | +·011                               | S. E.           | W.       | 4   | 1                        | 0·33                                     | Fine.      |
| Mergui .....     | 29·948                                      | +·005                               | N. E.           | N.       | 1   | 8                        | 1·55                                     | Cloudy.    |



| Vessel.       | Hour.  | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter.                                  | Winds.   |                                | REMARKS.   |
|---------------|--|-----------------|------------------|--|--|--------------------------------|--|
|               |  |                 |                  |  | Dir.   | Force.                         |  |
| Asia .....    | 4 A. M.<br>8 A. M.<br>Noon<br>4 P. M.  | 13° 26'         | 93° 27'          |  | S W by S.<br>S. S. W.<br>...<br>S.                                       | Mode-<br>rate.<br>...<br>Light | Moderate breeze and<br>fine weather during<br>the day.<br>Light breeze.  |
| Shazada.....  | 8 A. M.<br>Noon<br>4 P. M.   | 14° 05'         | 90° 50'          | 29·841<br>·758   | W. N. W.<br>N. N. W.   | Mode-<br>rate.<br>Light        |  |
| Chanda .....  | 4 A. M.<br>8 A. M.   | 15° 27'         | 95° 15'          | 29·860<br>·860   | S. S. W.<br>S. S. W.   | 5<br>3                         | Clear weather.   |
| Bancoora ...  | 4 A. M.<br>8 A. M.<br>Noon<br>4 P. M.<br>8 P. M.<br>Midnt.                                   | 15° 51'         | 93° 50'          | 29·927<br>...<br>·899<br>·812<br>·907<br>·897                          | W. S. W.<br>W. S. W.<br>S. E.<br>S.<br>E. S. E.<br>S. E.                 | 3<br>3<br>3<br>3<br>2<br>2     | 4 A. M. Heavy norther-<br>ly sea. Ship rolling<br>heavily. 6 A. M. Mo-<br>derate breeze, heavy<br>confused sea, ship<br>rolling violently.<br>Noon. Pleasant breeze<br>and cloudy.   |
| Mount Stuart  | 4 A. M.<br><br>Noon<br>4 P. M.<br>8 P. M.<br>Midnt.  | 15° 51'         | 91° 30'          | 29·890   | Varies to<br>W.<br>...<br>N. W.<br>...<br>N. N. W.                       | 5<br>5<br>3<br>2<br>1 to 2     | Heavy cross N. N. W. to<br>N. N. E. sea which gra-<br>dually abated. A flash<br>of lightning ahead<br>at 3 A. M. Passing<br>clouds, weather gradu-<br>ally getting finer look-<br>ing. Passed through<br>lots of bamboo roots<br>to-day. Fine moon-<br>light night.  |
| Byculla ..... | 2 A. M.<br>4 A. M.<br>6 A. M.<br>8 A. M.<br>10 A. M.<br>Noon<br>4 P. M.<br>8 P. M.<br>Midnt. | 15° 58'         | 93° 58'          | 29·780<br>·760<br>·820<br>·860<br>·890<br>·890<br>·880<br>·920<br>·950 | S. W.<br>...<br>...<br>S.<br>...<br>...<br>S. W.<br>S. S. W.<br>S. S. E. |                                | 2 A. M. Fresh breeze<br>and cloudy.<br>4 A. M. Moderate breeze<br>and cloudy, with pass-<br>ing squalls. 7 A. M.<br>Water very much dis-<br>coloured, muddy ap-<br>pearance, bottom 28<br>fathoms. Moderate<br>breeze and cloudy,<br>light passing squalls.<br>0·40 P. M. Sighted<br>Alguada Light House<br>to S. E. 1·30 P. M.<br>Light breeze and fine<br>with smooth water. |

| Vessel.       | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.   |        | REMARKS.  |
|---------------|---------|-----------------|------------------|---------------------------------------|----------|--------|---|
|               |         |                 |                  |                                       | Dir.     | Force. |   |
| Satara .....  | 4 A. M. |                 |                  | 29·730                                | S. S. E. | 7      | Moderate gale accom-<br>panied with heavy<br>squalls of wind and<br>rain. 4 A. M. Strong<br>breeze with heavy<br>squalls. 5 A. M. Very<br>dirty weather, wind<br>moderating, very<br>heavy squalls, and<br>sharp rain. 6-30 A. M.<br>Sighted land. 8 A. M.<br>Strong breeze and<br>thick dirty weather.<br>10 A. M. Fresh breeze,<br>weather clearing up<br>generally, occasional<br>heavy squalls. Noon.<br>Light breeze and fine.<br>Sea smooth. 4 P. M.<br>Light breeze and fine,<br>8 P. M. Sighted Al-<br>quada Reef Light.<br>Moderate breeze and<br>fine. Sea smooth.<br>Midnight. Light<br>breeze and fine. |
|               | 8 A. M. |                 |                  | ·850                                  | S. S. W. | 6      |   |
|               | Noon    | 16° 45'         | 94° 3'           | ·880                                  | ...      | 2      |   |
|               | 4 P. M. | *               |                  | ·730                                  | ...      | 2      |   |
|               | 8 P. M. |                 |                  | ·900                                  | ...      | 4      |   |
|               | Midnt.  |                 |                  | ·900                                  | S. W.    | 2      |   |
| Scottish Hill | 4 A. M. |                 |                  | 29·820                                | W.       |        | Sky clearing. Sea<br>lighter, though much<br>confused. Heavy sea<br>from N. N. W. and<br>N. Weather fine,<br>but heavy bank of<br>clouds to N. N. W.<br>and N. N. E. Sea<br>going down fast.<br>Clouds clearing off.  |
|               | 8 A. M. |                 |                  | ·870                                  | ...      |        |   |
|               | Noon    | 17° 00'         | 92° 25'          | ·880                                  | ...      |        |   |
|               | 8 P. M. |                 |                  |                                       | W. N. W. |        |   |
|               | Midnt.  |                 |                  | ·890                                  | N. W.    |        |   |
| Loanda .....  | 4 A. M. |                 |                  |                                       |          |        | Wind hauled round<br>through N.<br>Weather overcast with<br>light rain.<br>Weather improving.   |
|               | Noon    | 17° 34'         | 92° 46'          |                                       | W.       | 7 to 8 |   |
|               | Midnt.  |                 |                  |                                       |          |        |   |
| Mahratta ...  | 4 A. M. |                 |                  | 29·590                                | N. N. E. | 9      | Thick continual rain,<br>with heavy sea   |
|               | 8 A. M. | Entered<br>ab.  | d Aky-           | ·740                                  | N. N. W. | 8      |   |

\* A current set the ship from noon of 11th instant to noon of 14th instant N. 13° W. 171 miles.

The barometer had risen at Diamond Island and all the stations to the south and east, except Nancowry, where a slight fall was observed.

The rise was nowhere large, and was less than a tenth of an inch at all stations in that part of the Bay. A considerable ( $\cdot 17''$ ) fall had occurred at Akyab, and smaller changes of the same character at Chittagong and Toungoo. Judging from the barometric movements, the centre at 10 A. M. was in the immediate neighbourhood of Akyab.

The wind observations, however, are anomalous and almost unintelligible on the supposition of a well defined cyclonic circulation. The winds at Nancowry were steady from south-west, but were very feeble. At Port Blair, the wind was very unsteady, shifting from W. N. W. at 10 A. M. to S. S. E. at 4 P. M. Moderately strong S. W. winds continued at Diamond Island. The winds at 10 A. M. at Akyab were from N. and at Chittagong and Toungoo from N. W. They shifted at 4 P. M. to west at Akyab and Chittagong, and to S. W. at Toungoo. They were, however, very feeble at all these stations. The wind velocity averaged 8 miles per hour at Akyab, and only 1 mile per hour at Chittagong, where the air motion was actually less than the average in November, which is 2 miles per hour. The only inference from these observations is, that the cyclonic or vorticose motion had been broken up to a large extent by the action of the hills and the friction of the land, and that it was no longer a well-defined cyclonic circulation. This is also indicated by the character of the rainfall at the land stations. It was more widely distributed than before, and was smaller in amount, the largest quantity registered being 2.44 inches at Akyab.

The vessels which have contributed logs were all on the southern and western quadrants at some distance from the centre. They give information which is less valuable and conclusive than that of the preceding days. The whole of the meteorological observations, when charted, indicate that the centre of the barometric depression at 10 A. M. was to the east of Akyab in Lat.  $20^{\circ}$  N. and Long.  $93\frac{1}{2}^{\circ}$  E., and that the cyclonic circulation was very irregular and fast breaking up. The Mahratta, from Chittagong, entered Akyab harbour at 8 A. M. She had thick continued rain during the night with northerly winds of force 9. The Scottish Hill, in Lat.  $17^{\circ}$  N. Long.  $92^{\circ} 25'$  E., was to the south of the centre at noon. She had winds from west to north-west. During the day, the sky cleared, and the sea went down. At noon, weather was fine, although a heavy bank of clouds was still to be seen to the N. N. W. and N. N. E., but it cleared off during the night.

The Loanda, in Lat.  $17^{\circ} 34'$  N. and Long.  $92^{\circ} 46'$  E. by account, had westerly winds, and overcast skies with slight rain.

The Satara found herself at noon in Lat.  $16^{\circ} 45'$  N. and Long.  $94^{\circ} 3'$  E. She experienced moderate winds of force 7 from S. S. E. early in the morning, and continued to have sharp squalls and heavy rain until

6 A. M., after which the weather rapidly improved. A fresh breeze was blowing at 10 A. M. with occasional heavy squalls. At noon, the storm was completely over, and she had light breezes of force 2 from the S.S.W., fine weather, and a smooth sea.

The Mount Stuart, in Lat.  $15^{\circ} 51'$  N. Long.  $91^{\circ} 30'$  E. at noon, had westerly winds of force 5 early in the morning, with a heavy cross sea. The weather improved rapidly, and was quite settled in appearance at night, with fine clear skies and light winds of force 1 to 2. The Byculla, Bancoora, and Chanda were steaming along the south coast of Burmah towards Rangoon. They had fine weather with south-westerly winds of average force 3.

It thus appears that the first action of the Burmese hills, which are comparatively low, had been to retard the advance of the centre very considerably between noon of the 12th and of the 13th. During the next 24 hours, it advanced rapidly almost due northwards with a very slight easterly tendency. It then approached the coast to the east of Akyab on the morning of the 14th. The depression was, however, very much smaller than hitherto, and the cyclonic motion very considerably broken up. The winds were irregular in direction near the centre. The rainfall was evidently much less in amount, and more widely distributed. The observations taken at Akyab and Chittagong at 4 P. M. shew that the disturbance was then almost completely disintegrated. There was at that hour an irregular, but very feeble, cyclonic circulation, which passed away before the following morning.

*15th November.*—The meteorology of the 15th is given to show how completely the cyclonic disturbance had broken up.

The barometric changes of the previous 24 hours were exceedingly irregular. The only important change was in Arakan, where the barometer had risen very rapidly with the disappearance of the cyclonic disturbance. The winds show very little alteration generally. In the North-West Provinces and Punjab, they were very variable. In Bengal and Orissa, they had a much stronger northerly component than is usual in November. The weather was fine, and skies were clear over nearly the whole country, except Burmah and Arakan, where they were still more or less clouded, and moderate rain was falling. In the Punjab, though the sky was generally clear and humidity decreasing, the weather still appeared unsettled. The exceptional character of the weather in the Punjab during the previous week, is illustrated by the fact that the average rainfall of the hill stations at Simla and Chakrata for the month of November is *nil*, whilst, during the previous fifteen days, four inches had fallen at the former station, and  $3\frac{1}{2}$  inches at the latter.



The following tables give the observations of the same stations as hitherto, and the meteorological information from the logs of several vessels in the Bay for the 15th November :—

| Stations.        | Barometer at 10 A. M. reduced to sea level. | Change since 10 A. M. previous day. | Winds.   |          | Velocity in miles per hour since 10 A. M. previous day. | Cloud amount at 10 A. M. | Rainfall at 10 A. M. preceding 24 hours. | Weather.   |
|------------------|---|-------------------------------------|----------|----------|---|--------------------------|--|------------|
|                  |   |                                     | 10 A. M. | 4 P. M.  |   |                          |  |            |
| Nancowry .....   | 29·889                                      | —·032                               | E.       | S.       | 2   | 8                        | 1·47                                     | Cloudy.    |
| Port Blair ..... | 29·932                                      | +·008                               | N. N. E. | E. S. E. | 5   | 3                        | 0·13                                     | Fine.      |
| Diamond Island   | 29·937                                      | +·039                               | E. S. E. | E. S. E. | 7   | 6                        | 0·16                                     | Fine.      |
| Akyab .....      | 29·937                                      | +·245                               | E.       | S. S. E. | 5   | 9                        | 0·33                                     | Gloomy.    |
| Chittagong ...   | 29·925                                      | +·153                               | S. S. E. | S. S. W. | 2   | 6                        |  | Gloomy.    |
| Toungahoo .....  | 29·913                                      | +·047                               | N. W.    | N. W.    | ?   | 6                        | 0·04                                     | Drizzling. |
| Bassein .....    | 29·952                                      | +·030                               | S. S. E. | W.       | 3   | 10                       | 0·04                                     | Cloudy.    |
| Rangoon .....    | 29·952                                      | +·031                               | S. E.    | S. S. E. | 5   | 9                        | 0·74                                     | Cloudy.    |
| Moulmein .....   | 29·899                                      | —·014                               | N.       | N. E.    | 2   | 0                        |  | Fine.      |
| Mergui .....     | 29·920                                      | —·028                               | Calm.    | N.       | 1   | 10                       | 1·50                                     | Overcast.  |

| Vessel.      | Hour.                                 | Latitude.<br>N. | Longitude.<br>E. | Probable reduced barometer. | Winds.   |        | REMARKS.   |
|--------------|---------------------------------------|-----------------|------------------|-----------------------------|----------|--------|--|
|              |                                       |                 |                  |                             | Dir.     | Force. |  |
| Shazada..... | 4 A. M.                               | 12° 47'         | 87° 14'          | 29·911                      | N. N. E. | Light. | Weather fine with light winds.                     |
|              | 8 A. M.<br>Noon<br>4 P. M.<br>8 P. M. |                 |                  | ·781                        | N. N. E. | Light. |  |
| Satara ..... | 4 A. M.                               | 15° 50'         | 95° 50'          | 29·870                      | S. E.    | 2      | Light breeze and fine clear weather.               |
|              | 8 A. M.                               |                 |                  | ·940                        | ...      | 4      | Moderate breeze and fine weather.                  |
|              | Noon                                  |                 |                  | ·980                        | ...      | 4      | Current during the previous 24 hours, W. 65 miles. |
|              | 4 P. M.                               |                 |                  | ·810                        | N. E.    | 2      | Light breeze and fine weather.                     |

| Vessel.       | Hour.   | Latitude.<br>N. | Longitude.<br>E. | Probable re-<br>duced baro-<br>meter. | Winds.            |        | REMARKS.                                       |
|---------------|---------|-----------------|------------------|---------------------------------------|-------------------|--------|--|
|               |         |                 |                  |                                       | Dir.              | Force. |  |
| Asia .....    | 4 A. M. |                 |                  |                                       | Variable          | Light  | Light and variable airs,<br>fine weather.      |
|               | Noon    | Port            | Blair.           |                                       | ...               | ...    |  |
|               | 4 P. M. |                 |                  |                                       | E. N. E.          | Light  | Light breeze and fine<br>clear weather.        |
|               | 8 P. M. |                 |                  |                                       | ...               | Fresh. |  |
| Mount Stuart  | 4 A. M. |                 |                  |                                       | N. N. W.          | 1      | 1 P. M. Smooth with<br>light N. swell. 4 P. M. |
|               | 8 A. M. |                 |                  |                                       | N. by E.          | 1 to 2 | Heavy clouds all<br>round the horizon.         |
|               | Noon    | 16° 24'         | 92° 00'          | 29° 8' 90"                            | N. N. E.          | ...    | 5 P. M. Weather set-<br>tled looking.          |
|               | 4 P. M. |                 |                  |                                       | NE by N           | 2      |  |
|               | Midnt.  |                 |                  |                                       | NNE to<br>NE by N | 2      | Midnight. Clear fine<br>weather.               |
| Scottish Hill | 8 A. M. |                 |                  |                                       | N. W.             |        | Light winds and swell<br>from N. N. W.         |
|               | Noon    | 18° 03'         | 92° 48'          | 29° 9' 00"                            | ...               |        |  |
|               | 8 P. M. |                 |                  |                                       | NNW to<br>N.      |        | Light winds and clear<br>sky.                  |
| Loanda .....  | Noon    | 18° 38'         | 92° 30'          | 29° 8' 00"                            | W by N.           | 5      |  |

The observations call for little remark. The rapid recovery of pressure at Akyab, and the lightness and irregularity of the winds in Arakan and Burmah, indicate the complete disappearance of the cyclonic vortex. The land observations show that the winds were very unsteady during the day. For instance, at Nancowry, they were from east at 10 A. M. and south at 4 P. M. Similarly, at Port Blair, they shifted from N. N. E. at 10 A. M. to S. S. E. at 4 P. M. It is probable that these were light local winds, for the logs of the vessels prove that, over the greater part of the Bay, north-easterly winds were again established. The *Clan Macpherson*, at the entrance to the Bay, in Lat. 6° N., had moderate north-easterly winds.

Hence the cyclonic circulation had not only broken up, but the south-westerly winds which had, as shown by the Nancowry registers, prevailed steadily up to the afternoon of the 14th, although they had decreased in strength considerably during the 12th, 13th, and 14th, had given way so

rapidly and entirely on the afternoon of the 14th, that light north-easterly winds were again established over nearly the whole of the Bay on the morning of the 15th. This speedy restoration of the normal circulation of the air after the disappearance of the disturbance, is perhaps less remarkable than it might seem to be, but is nevertheless noteworthy.

#### CHAPTER IV.

##### DISCUSSION OF THE CHIEF FEATURES OF THE STORM OF NOVEMBER 10TH TO 15TH.

The following gives a brief connected narrative of the more important features of the storm.

After the termination of the south-west monsoon in Bengal in the last week of September 1883, the winds shifted round to north over the Head of the Bay, and the lower air current of the south-west monsoon recurved over the middle of the Bay. The north-east monsoon hence commenced on the Madras coast during the first week of October. Unusually heavy rain fell over Southern India, more especially over the eastern districts of the Madras Presidency, during the month of October and the first week of November. During the whole of this interval, the period of the year when the most severe and extensive cyclones are known to occur, the Bay was entirely free from storms. In the beginning of the second week of November, the rainfall rapidly decreased in amount in Madras, and ceased entirely on the 9th and 10th. The logs of vessels shew that winds were, at that time, as they had been for some days previously, very light and variable in the neighbourhood of the Andamans and Nicobars. South-westerly winds were re-established at Nancowry on the 4th, and south-easterly winds at Port Blair on the 7th, but they were at first very weak.

The wind observations taken on board the ships *Mount Stuart* and *Scottish Hill* prove that, at the same time, winds were unusually light over the centre of the Bay, in the neighbourhood and to the west of the Nicobars and the Andamans. This condition of excessively feeble air motion was very marked on the 7th and 8th. On the 9th, there were indications for the first time of the occurrence of moderately heavy and localized rainfall to the north-east of the Nicobars, and to the east of Port Blair, and also of a shift of wind, significant of the commencement and establishment of cyclonic circulation. On the morning of the 10th, there was a well-defined atmospheric whirl to the east of Port Blair. Weather was at that time cloudy, with very light breezes, and occasional passing showers; and the sea was smooth, and free from any considerable current over the greater part of the Martaban Gulf, and the north and centre of the Bay.



The ship Kwang Tung, it may be remarked, passed, on the 7th and 8th, over the area in which the disturbance was generated; and there is not the slightest indication in her log, or in the observations of the neighbouring land stations, of the existence of any atmospheric whirl, large or small, at that time, or previous to the 10th. The central depression at noon on the 10th was very small, probably less than a tenth of an inch, and the atmospheric whirl, although clearly established, was as yet in an initial state. It, however, rapidly acquired increased energy during the afternoon of the 10th, and the morning of the 11th. At noon of the 11th, there was a well-defined cyclonic disturbance with its centre in Lat.  $13\frac{1}{2}^{\circ}$  N. and Long.  $94\frac{1}{4}^{\circ}$  E., the barometric depression at which certainly exceeded '3". Strong winds were now blowing into it from the south, and bringing up much vapour. During the succeeding 24 hours, the centre moved to the north-westward through the channel separating Diamond Island and Cape Negrais from the Andaman Islands, and probably over the Coco Islands. Its centre, at noon on the 12th, was in Lat.  $15\frac{1}{2}^{\circ}$  N. Long.  $93^{\circ}$  E. The disturbance was of small extent, as vessels at distances of only 150 miles had light to moderate winds of force 3 to 5. The Satara, Byculla, and Loanda, all of which were near the centre, on the other hand, experienced squalls of terrific and hurricane force.

Hence it was at that time a small but well-defined atmospheric whirl or cyclonic disturbance. The winds and squalls near the centre were of the most violent character, the sea excessively high and dangerous, and the currents in the eastern quadrant considerable. During the next 24 hours, it retained the same characteristics, but moved very slowly to the north, so that, at noon, its centre was in Lat.  $16^{\circ} 10'$  N. and Long.  $93^{\circ}$  E. The retardation of its motion was evidently due to the resistance of the land and hills in the eastern quadrant. The centre passed a few miles to the east of the Loanda and the Byculla on the evening of the 12th and morning of the 13th. The decrease in the indraught from the eastern quadrant due to the action of the Burmese and Arakan coasts continued. The whirl began to diminish in intensity, and also recurved slightly after noon of the 13th, and passed to the north-north-eastward, thus approaching the Burmese and Arakan coasts. On the morning of the 14th, it was much enfeebled. The barometric depression was smaller in amount, the winds weaker, the rainfall more diffuse and less localised, and the sea less violent. Moreover, the directions of the winds were so irregular over the area of barometric depression as to suggest the existence of several imperfect and feeble vortices, rather than of one large and well-defined whirl. The centre of the depression was in the neighbourhood of Akyab on the morning of the 14th. The land observations at 4 P. M. of that day



indicate that the cyclonic circulation was completely broken up, and that fine weather, with moderate winds, and a slight sea, obtained at that hour in the north-east of the Bay, over which the cyclone had previously advanced. The disturbance passed so completely away on the 14th that normal north-easterly winds were re-established over the greater part, if not the whole, of the Bay, on the morning of the 15th. The storm hence was generated and dispersed between the morning of the 10th and the evening of the 14th.

The following are a few of the more important points in connection with this cyclone.

One of the more remarkable features, which has already been discussed, but which deserves special mention, was the change which occurred when the cyclone approached the Burmese coast. Whatever the explanation may be, there can be no doubt of the facts.

The following table gives approximately the position of the centre at noon on the various days, and the distance passed over by it in the preceding 24 hours :—

|            | Position of Centre. |            | Distance passed over in preceding 24 hours. |
|------------|---------------------|------------|---|
|            | Latitude.           | Longitude. |   |
| 11th ..... | 13° 30'             | 94° 15'    |   |
| 12th ..... | 15° 30'             | 93° 0'     | 160 miles.                                  |
| 13th ..... | 16° 10'             | 93° 0'     | 47 „  |
| 14th ..... | 20° 0'              | 93° 30'    | 275 „                                       |

It will thus be seen that, between noon of the 12th and 13th, the storm centre began to recurve, and only advanced a distance of about 50 miles, as compared with 160 miles during the previous 24 hours, and 275 during the succeeding 24 hours. The only apparent explanation depends on what I have already suggested as probable, namely, that the cyclonic action extends through very different heights in different storms. In the storms of the rains proper, it is almost certain that the condensation, and therefore the seat of the disturbance, is at a much greater elevation than it is in storms formed during the October Transition period. In the latter case, the storms appear to be generated

near the northern limit of the retreating south-west monsoon current, which is at that period diminishing in strength. It is probably much shallower at its northern limits than elsewhere. Many of the phenomena of the cyclones of the Bay appear to be intelligible and explicable only on this supposition.

If it be granted that the October and November storms of the Bay of Bengal are formed near the northern edge of a diminishing and retreating current, it is hence almost certain that the vapour condensation, in the case of the November cyclone under discussion, occurred at a comparatively small height in the atmosphere, and that the resulting motion was mainly confined to the lower strata. Hence the effects due to friction with land, and to the destructive or disintegrating action of the hill barriers of Burmah and Arakan cutting almost radially across the cyclonic area, would be large and marked. This was undoubtedly the case. So long as the cyclone was to the south of the Burmah coast, the cyclone increased in intensity. When the centre was in a line with the coast, and at a short distance from it, retardation was at once shown, and the cyclonic or vorticose motion began to diminish. And as the centre advanced northwards, so that the Arakan hills (of greater height than the west Burmese hills) were included within the area of disturbance, the disintegrating action became rapidly more marked, and caused a speedy disruption of the vortex.

A feature which deserves special notice in the smaller cyclonic storms of the Bay is the behaviour of the barometer. The barometer affords practically no indication of the approach of a small cyclonic storm in the Bay, and should not be trusted by the mariner to give due warning. The reason of this is simple. A favourable condition antecedent to the formation of a storm is approximate uniformity of pressure over the whole or a large portion of the Bay. If a small atmospheric whirl be set up in an almost quiescent mass of air, which is therefore under nearly identical and uniform conditions, it produces a small depression at and near the centre, which extends slowly outwards. The fall of the barometer at distances of 80 or 100 miles from the centre is generally small in amount, and is frequently less than the changes due to general actions common to the whole of India. The depression at the centre rarely exceeds half an inch, and steep baric gradients are confined to its immediate neighbourhood. Over the rest of the Bay, the pressure is slightly affected by the indraught, but frequently not to such an extent as to obscure the changes going on over the whole of India. In other words, during the formation and existence of a small storm, the barometer immediately outside of the storm area proper oscillates in obedience to the larger atmospheric movements com-

mon to the whole of India, as well as to the distant storm, and hence, if used as a guide to the weather, it should be remembered that its indication may refer mainly to these general movements, and not to the whirl in the neighbourhood. Hence it cannot be used as a reliable guide to the existence of small storms in the Bay of Bengal.

A few examples from the present cyclone will not only indicate that the barometer gives no certain and marked warning of the approach of a smaller cyclone in the Bay, but suggest that the mariner in the Bay of Bengal should rely mainly on the appearance of the sky, the strength and changes of the wind, the amount of the swell, and the direction from which it travels, as indications of an approaching storm.

The Mount Stuart passed through the western quadrant. The following table gives her barometric readings, her position with respect to the storm centre, strength of wind, and amount of swell:—

|           | Barometer. | Wind.  | Swell.     | Distance of storm centre. | Weather.                  |
|-----------|------------|--------|------------|---------------------------|---------------------------|
| 7th ..... | 29·90      | 2 to 3 | None       | ...                       | Unsettled.                |
| 8th ..... | ·92        | 1 to 4 | None       | ...                       | Unsettled.                |
| 9th ..... | ·87        | 0 to 3 | None       | ...                       | Unsettled.                |
| 10th ...  | ·86        | 0 to 4 | None       | ...                       | Unsettled.                |
| 11th ...  | ·82        | 2 to 5 | None       | 250                       | Weather looking very bad. |
| 12th ...  | ·75        | 5 to 6 | ...        | 100                       | Squally.                  |
| 13th ...  | ·87        | 5 to 6 | Heavy sea. | 125                       | Squally.                  |
| 14th ...  | ·89        | 5 to 1 | Heavy.     | 280                       | Fine.                     |

The preceding table shows that, although she was within 100 miles of the centre of a storm between the 10th and 14th, the range of the barometer at noon during the whole interval was only ·14", or very little more than the diurnal range of the barometer in the Bay.

The Bancoora may be taken for another example:—

|          | Barometer. | Distance. | Wind.  | Swell.   | Weather.     |
|----------|------------|-----------|--------|--|--------------|
| 11th ... | 29·887     | 550       | 2 to 4 | None.  | Fine.        |
| 12th ... | ·805       | 250       | 4 to 5 | Heavy N. E. sea.   | Squally.     |
| 13th ... | ·770       | 70        | 3 to 7 | Tremendous sea in the morning. Heavy sea during the afternoon. | Very squally |
| 14th ... | ·839       | 280       | 2 to 3 | Heavy sea.   | Improving.   |



The above shows that the Bancoora, which left the River Hooghly on the 11th, approached within 70 miles of the centre of the cyclone at noon of the 13th. She had heavy squalls and a tremendous sea, and yet the total range of her barometer, as determined by the noon observations, was only  $\cdot 117''$ , or actually less than the diurnal range of the barometer in the Bay.

The Satara furnishes equally strong evidence. She was for a considerable time in the eastern quadrant of the cyclone at no great distance from the centre, and hence felt the full force of the storm.

|          | Barometer. | Distance. | Wind.  | Swell.     | Weather.             |
|----------|------------|-----------|--------|------------|----------------------|
| 10th ... | 29.89      |           | 2 to 5 | None.      | Fine.                |
| 11th ... | 80         | 250       | 4 to 6 | Heavy sea. | Gale. Heavy squalls. |
| 12th ... | 61         | 90        | 9      | Heavy sea. | Hard gale.           |
| 13th ... | 68         | 35        | 8 to 9 | Heavy sea. | Strong gale.         |

The preceding observations show that on the 11th, when the state of the sea and the strength of the wind indicated the existence of a cyclonic storm, her barometer had not fallen a tenth of an inch. It was only on the 12th, when she was in the midst of the storm, and the wind had increased to force 9, and was blowing a hard gale, that the barometer began to fall to any considerable extent.

These examples appear to establish that the barometric movements are very small in the outer portion of the smaller cyclonic disturbances of the Bay, and are generally smaller than those due to the regular changes common to the whole of India. Hence the barometer gives little or no practical warning of the approach of a small cyclone in the Bay, and mariners should therefore rely mainly on other indications.

The path of the cyclone was contrary to all recorded experience of storms in the Martaban Gulf. The following is the list of storms that have been known to occur in that portion of the Bay, taken from Mr. Blanford's Catalogue of the recorded Cyclones in the Bay of Bengal, up to the end of 1876, in *Journ. As. Soc., Bengal*, 1876, Vol. XLVI, Pt. II:—

1840—November 21st. To the N. E. of the Andamans.

1844—November 9th—14th. East of the Andamans. Encountered by



the Briton and Runnymede troop ships. Both vessels were dismantled and thrown on the Andamans.

1850—November 17th—19th. In the Andaman Sea. Passed east of Port Blair and travelled N. N. W.

1854—April 21st—23rd. A violent hurricane in the Gulf of Martaban and Rangoon.

1858—April 9th—10th. A storm from the Andamans to Cape Negrais. Much destruction of property occurred at Henzada and Rangoon, between which the centre passed.

There is no direct evidence in this list that any of these storms passed from the Martaban Gulf into the Bay of Bengal. It is, however, probable that the third storm in the list did so. It appears to be parallel in time of occurrence, and line of advance, with the storm under discussion. There is no apparent theoretical reason in support of the opinion that a storm generated in the Gulf of Martaban should not pass into the Bay. Experience certainly appears to indicate that such a line of motion is very rare. The great majority of the cyclonic storms in the Gulf of Martaban are generated to the east of the Andamans and north-east of the Nicobars, and advance in a general northerly direction across the south coast of Burmah, when they rapidly break up.

Hence, although experience is doubtless valuable in indicating the probabilities of the occurrence of cyclones, and their line of motion, it should be most carefully borne in mind, that they are mere probabilities based, at the present time, on very limited experience, and that it would almost certainly be misleading and dangerous to dogmatize our limited experience into rules or laws, which might fail on their first application.

Another feature deserving notice was the short period of its existence. Favourable conditions, according to the condensation theory, were present for some days previous to the 10th. The log of the Kwang Tung for the 7th proves that there was no cyclonic vortex in existence in the Andaman Sea on that day. The various observations of the 8th and 9th indicate that cyclonic motion on a considerable scale had not commenced on either of these days. The observations of the 10th, on the other hand, establish the existence of a small depression on that day which rapidly developed into a large atmospheric whirl. Hence the existence of the cyclonic vortex dates from the evening of the 9th, or morning of the 10th. The circulation intensified and developed rapidly on the evening of the 10th and morning of the 11th, so that there was a large barometric depression and cyclonic circulation on that day, to the north-east of the Andamans. The cyclone was then moving north-westwards.

It continued to accumulate energy until the morning of the 12th, when the action of the land on the atmospheric motion in the eastern and north-eastern portions of the cyclone retarded the advance of the vortex, and began to influence the cyclonic motion considerably. This proceeded at first slowly, but, as the storm moved northwards, the destructive effect of the Burmese and Arakan hills increased, so that the rotatory motion was gradually and completely broken up and disintegrated before the afternoon of the 14th, in the neighbourhood of Akyab. There was thus a period of about 48 hours, from the morning of the 10th to that of the 12th, during which the storm accumulated energy. During the next 24 hours, the rotatory motion continued almost undiminished, whilst the motion of translation was largely decreased. During the remaining 36 hours of its existence, the vorticose or rotatory motion was gradually diminished.

The force of the winds at and near the centre (which might perhaps be used to measure the intensity of the storm) depends mainly upon the strength of the atmospheric disturbance producing the cyclonic motion, that is, upon the rate at which aqueous vapour is condensed into rain and upon the character and distribution of the rainfall (*i. e.*, whether it is localized and concentrated over a comparatively small area or diffused). On the other hand, the extent of area over which the cyclonic disturbance extends appears to depend mainly, if not entirely, upon the length of time that has elapsed from its formation, and during which it has advanced over the sea area uninfluenced by the land. Hence it is that the most extensive cyclones have been generated in the centre of the Bay, near the Andamans, and have advanced northwards to the Bengal coast. This is not due to any meteorological peculiarity of the Bay in the neighbourhood of the Andamans, but to the fact that a cyclone generated there, and advancing northwards, takes a longer time to reach the land than if it were formed in any other part of the Bay, and has therefore a longer period during which its energy can increase.

## CHAPTER V.

### CONCLUDING REMARKS ON THE CONDENSATION THEORY.

In the preceding pages, all the observations throwing light on the two largest and most severe storms in the Bay of Bengal during the year 1883 have been given, together with a discussion of their more important features. It remains to explain the chief features of the two storms as physical phenomena, and hence also to suggest the theory of cyclonic generation and motion which appears to be applicable to them, and is consistent with our knowledge of the physics of the atmosphere.

In both examples, the greater portion of the mass of air that was thrown into a state of violent motion during the storm was for some days antecedent to the disturbances almost at rest, and in a state of approximate equilibrium. There was a break in the rains immediately preceding the formation of the first storm, which is well-known to be a period of light and unsteady winds in Bengal, and over the Head of the Bay. The second storm occurred very shortly after the first break in the north-east monsoon rains on the Coromandel coast, and when, as the various observations prove, winds were very light and variable over the greater portion of the Bay. Hence the first and most striking feature of these cyclones was, that a vast amount of kinetic energy, or motion, was rapidly given to a large mass of air which, previously to that action, was in an almost quiescent state. The gradual increase of the motion was in those two examples proved from observations taken by vessels passing through the areas of disturbance. The transformation from the state of approximate quiescence to that of violent cyclonic motion in the Bay is consequently a continuous process, the successive stages of which can be fully traced. And the entire development of these, and of all storms in the Bay of Bengal, appears to be due to actions occurring over the Bay itself, and not to atmospheric conditions at a considerable distance from the area of cyclonic disturbance.

The question of cyclone generation is therefore essentially one of transfer of energy. Viewed in this light there are two subjects for enquiry :—

1st. The source and character of the energy which is transferred to the atmosphere, and transformed into the kinetic energy of a mass of air.

2nd. The conditions necessary for the transfer of energy under consideration.

If these two questions are fully answered, a satisfactory explanation will be given of cyclonic generation as a meteorological problem. The complete mathematical treatment of this subject as a dynamical question is beyond the scope of the present article.

The energy which is transformed during the generation and existence of a cyclone, and which maintains the cyclonic circulation against the various resistances opposing it, and therefore tending to disintegrate it, is undoubtedly the latent heat energy given out during the condensation of aqueous vapour contained in the atmosphere. In all cyclones of the Bay of Bengal that have hitherto been investigated, heavy and, in the majority of cases, torrential rain is the most prominent feature. It increases in amount during the generation of the cyclone, is excessive during the existence of the cyclone in its complete



form, and rapidly decreases during the disintegration of the cyclone, ceasing with the disappearance of the cyclonic vortex. It is thus a phenomenon parallel in character and duration with the cyclonic motion or disturbance.

It is also equally certain that when aqueous vapour is condensed into rain, practically the whole of the solar thermal energy utilized to perform the work of evaporation is given out by the mass of vapour during condensation, and is transferred to the adjacent mass of air. Major Cunningham's Hydraulic Experiments at Roorkee appear to establish that the sun's heat under the most favourable conditions, that is, dry weather and high air temperature, does not evaporate more than one-tenth of an inch *per diem* from the surface of slowly moving water. The inverse process of condensation, in consequence of certain features of air motion dependent on rainfall, usually proceeds much more rapidly, and frequently restores the aqueous vapour in the form of rain to the earth's surface at the rate of one to two inches per hour. Prolonged rainfall at the rate of 10 to 30 inches *per diem* for periods varying from 24 to 72 hours are by no means uncommon during the passage of the larger cyclones of the Bay of Bengal across the Bengal or Madras coasts. It is probable, judging from the expressions used by sailors to describe the rainfall during cyclones in the Bay, that it is more intense and prolonged than on land.

If we therefore compare the rates at which evaporation and condensation can occur, it is certain that the energy released during the act of condensation is transferred to the atmosphere with very great rapidity during heavy rainfall and probably at a rate occasionally amounting to 100, 200, or even 400 times that at which it was absorbed during the process of evaporation. The effect of a continuous fall of 20 or 30 inches of rain over any portion of the earth's surface would, on the assumption of Major Cunningham's results, be equivalent to that of a sun 250 times as powerful as our present luminary acting directly on the mass of the atmosphere above the area of rainfall, instead of indirectly by means of convection currents due to the heating of the earth's land surface. The action is also usually continuous, and is not interrupted, as in the case of the direct solar action, by the succession of night and day. There is therefore the strongest probability that so powerful a disturbing action can produce very large and rapidly accumulating effects on the mass of the earth's atmosphere affected and influenced by it in a comparatively short space of time.

There hence appears to be no doubt that the energy transferred to the atmosphere during heavy rainfall is very large, and that the source of the energy thus indicated is adequate from every point of view to account for the production of the largest and most intense cyclonic cir-



culations. Other causes of the origin of cyclones have been assigned, as, for instance, differences of pressure, friction between parallel winds blowing from opposite directions, &c., but the slightest consideration seems to show that none of these is sufficient to account for the enormous and continuous transfer of energy that occurs during the prolonged existence of a large cyclone. The strongest argument against these theories, in the case of cyclones of the Bay of Bengal, is, that experience has established that the larger the cyclone, the smaller are the antecedent differences of pressure, and the feebler are the winds blowing from opposite directions, immediately before the formation of the cyclonic vortex.

The following statements based on the preceding remarks hence give the answer to the first part of the required explanation. When water is converted into aqueous vapour on the large scale at the earth's surface, thermal energy, derived from the sun, performs the work of evaporation, and is hence transformed. The aqueous vapour thus produced possesses an equivalent amount of energy, the greater part, if not the whole, of which it retains, so long as it continues in the vaporous condition. When it is reconverted into water, or condensed as rain, this portion of its total energy is given out, and transferred to the air. The *modus operandi* of this transfer is a matter of no importance in the present enquiry. Also, in all cases when the rainfall is heavy, and prolonged for a considerable time, the energy is given out at a much more rapid rate than that at which it was absorbed during the process of evaporation. Hence heavy and prolonged rainfall may give rise to a powerful, persistent, and continuously accumulating disturbance on the adjacent atmosphere, and, therefore, produce violent and extensive air motion. In virtue of the constitution of the atmosphere, the motion will be rotatory. Prolonged heavy local rainfall is hence an adequate and sufficient cause. It is, moreover, the only known cause which is equal or similar in amount to the effect, and hence there are strong reasons for assuming that it is the motive power which produces the peculiar motion of the atmosphere called cyclonic circulation on the large scale. It is, in fact, the most powerful disturbing action to which the air is subject, and the consequent motion of the air is, when the rainfall and consequent disturbance are excessive, the most violent in its character with which we are acquainted.

The history of the two cyclones has shewn most fully that heavy rainfall over the area of cyclonic motion or disturbance was a characteristic feature, and that in this respect they confirm previous experience. Hence the source of the energy of these two cyclones was almost certainly that which we have indicated in the previous statement, that is, the latent heat energy of the aqueous vapour derived previously from the sun, and transferred to the atmosphere during the process of condensation.

As rainfall does not always appear to produce cyclonic motion, it is clear that, although rainfall may be the source of energy, it is only when the rainfall occurs under special conditions that the accompanying air motion increases and accumulates in the peculiar manner necessary to give rise to a large and intense cyclonic circulation. Experience has shown that the following conditions, which can be proved to have a direct bearing on the formation of cyclones, are always present before and during the generation of cyclones in the Bay of Bengal :—

1st. The establishment and prevalence of a humid current over the extreme south of the Bay, which brings up large quantities of aqueous vapour into the centre or north of the Bay.

2nd. The occurrence of approximate uniformity of meteorological conditions, more especially of pressure, over the coasts of the Bay, and frequently over a considerable portion of the Bay.

3rd. The prevalence of light and variable winds over Bengal and the coasts of the Bay, and over a considerable portion of the Bay extending from the Bengal coast southwards. This condition is practically identical with the previous, as both are due to, and accompany, the same general atmospheric conditions.

4th. The absence of rainfall, and the prevalence of clear skies with fine weather, over the north and centre of the Bay, and in Bengal.

The relative importance of these conditions will be evident on very brief consideration. The first is evidently necessary to supply the aqueous vapour in sufficiently large amounts to give rise to continuous heavy rainfall over such a large area as is covered by a considerable cyclonic disturbance. The Bay of Bengal is not a large enough evaporating area to afford such a supply. Hence cyclonic storms are only formed in the Bay of Bengal when there is a humid current blowing into it from the Indian Ocean. This occurs only during the south-west monsoon period, when the south-west winds blowing at the entrance of the Bay are the northward continuation beyond the Equator of the south-east Trade Winds of the Southern Tropics. That such is the case is sufficiently proved by the fact that cyclonic storms on the large scale are entirely restricted to that portion of the year when south-west monsoon winds are blowing over a part or the whole of the Bay, that is, from the beginning of May to the end of December. It is also shown by the fact that, at the commencement and termination of the south-west monsoon period, any cyclones that are generated, form in the south of the Bay, whilst in the months of July and August, or during the height of the south-west monsoon, they form near the Head of the Bay. In short, the area of cyclonic generation in the Bay of Bengal depends mainly upon the season, and travels northwards or southwards, according as the south-west monsoon is advancing or retreating over the Bay.

The remaining conditions appear to be necessary in order that the rainfall may occur in such a manner as to give rise to and produce an atmospheric whirl. It is evident that if rainfall tends to set up rotatory motion in the air, it is absolutely necessary for rotatory motion on the large scale that there should not be several separate centres of rainfall and disturbance, each producing its own rotatory or cyclonic action, and therefore interfering with the others. It is essential that the rainfall should be localized and concentrated, that it should continue for some time over a comparatively small area, and be confined to that area. The more perfectly this is realized, and the longer this continues, the greater will be the accumulated disturbance. In order that the rainfall may occur over the same area for such a considerable period as to permit of the continuous accumulation of action, it is evident that ascensional motion should mainly occur there, and hence that, previously, there should be little horizontal motion of the air, and therefore very slight differences of pressure at the sea level. The necessity for the further conditions is hence also evident.

It will be seen that these conditions were fulfilled in the case of both storms, more completely (as might have been anticipated) in the case of the second storm, when the south-west monsoon current was weaker than it was at the time of the first storm. The history and discussion thus fully bear out the existence of the conditions immediately antecedent to the two storms which the condensation theory asserts to be necessary for the initiation and generation of a cyclonic storm in the Bay.

The preceding remarks hence indicate that the energy given out during the process of aqueous vapour condensation on the large scale is the motive power of cyclones, and that the rainfall must be localized and concentrated over a considerable area, for a period of one or more days, in order to produce the continuous and rapid accumulation of energy which characterizes a large cyclonic disturbance. Experience has also shown that the conditions which the condensation theory suggests as being essential for the occurrence of continuous and prolonged local rainfall over a portion of the Bay are exactly those which are present before and during all cyclonic storms in the Bay of Bengal, and that they are more fully marked before the occurrence of the larger than of the smaller cyclones of the Bay. It is, moreover, these antecedent conditions which form the only test or indication of the possible or probable early formation of cyclones in the Bay, and which are utilized in the preparation of the daily weather Reports issued by the India and Bengal Meteorological Departments.


---



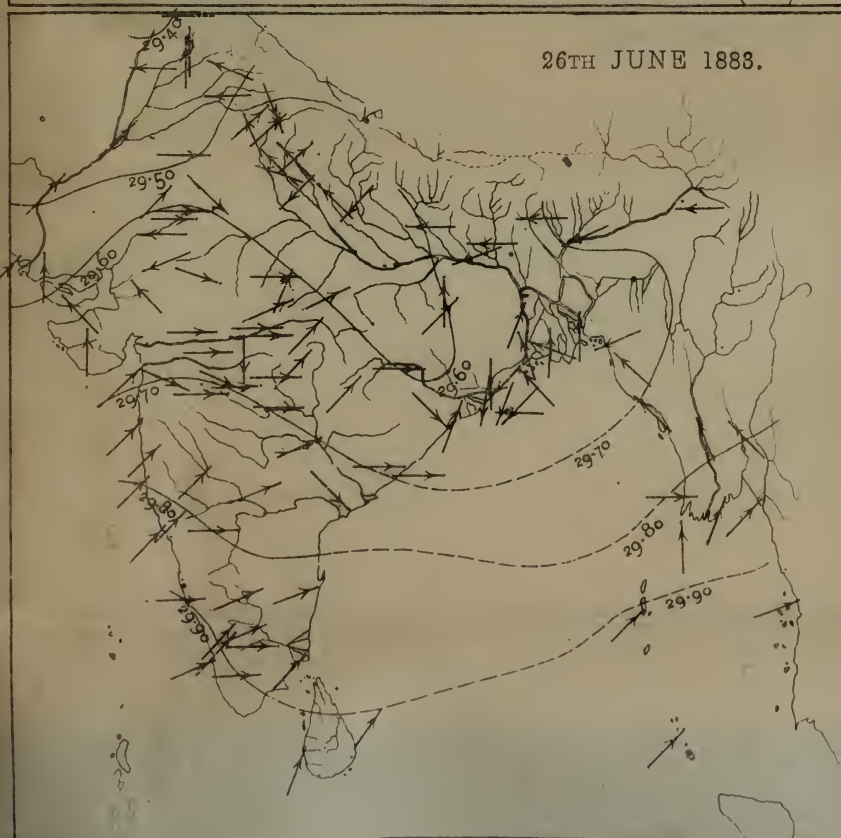
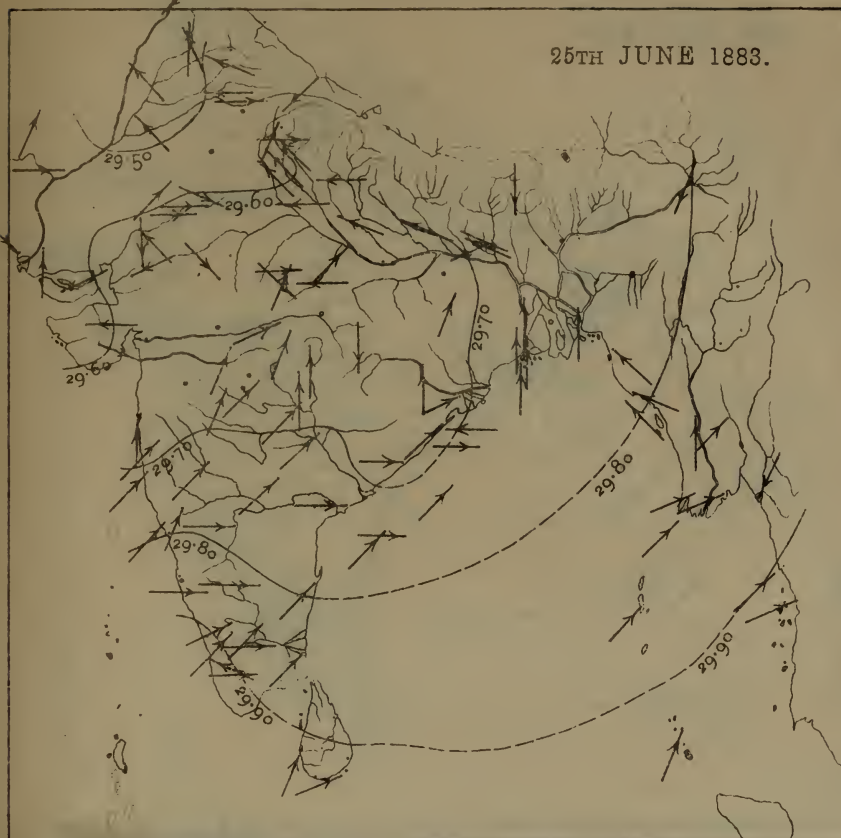
## EXPLANATION OF PLATES II—X.

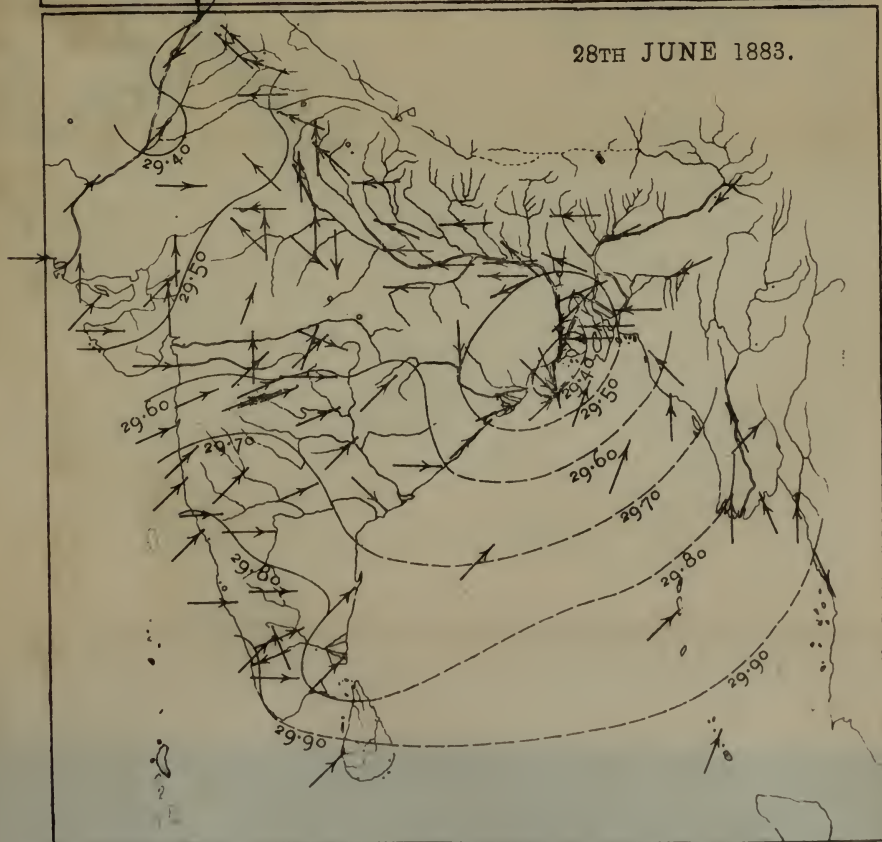
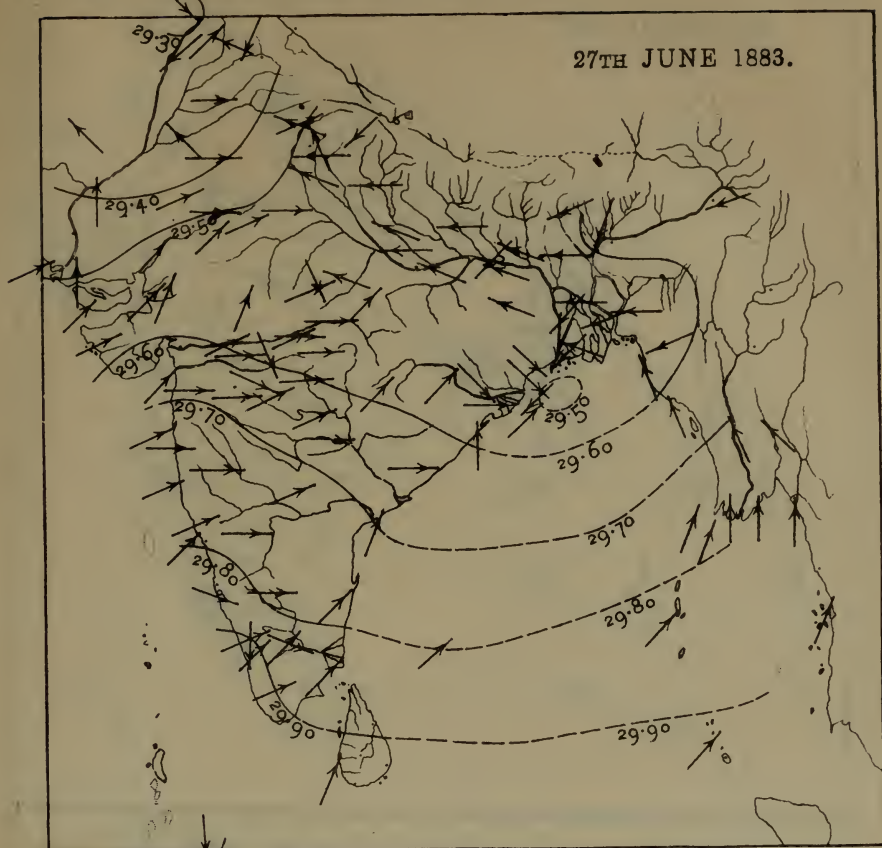
The plates give the weather charts for each day during the whole period covered by the two storms of 1883 described in the preceding pages. The curved lines or isobars indicate the distribution of pressure. Along any one of these lines, the estimated air pressure at the sea-level (as determined from the reading of the barometer) is the same. Hence no change of pressure occurs along these lines, and the change of pressure is greatest perpendicularly across these lines. The rate of change is most rapid where the lines are nearest together. As the difference of air pressure between consecutive lines is the same, the rate of increase or decrease of pressure is inversely proportional to the distance between consecutive lines. The isobars form closed curves about the centre of a cyclonic disturbance. Hence the position of the cyclonic vortex on any day is at once determined by an inspection of the charts. The probable path is determined by joining these positions by lines. The direction of the air motion near the earth's surface is determined by the winds, which are shown by arrows flying with the wind, or pointing to the direction towards which the moving air is advancing. Small circles (o) indicate a calm at the hour of observation.

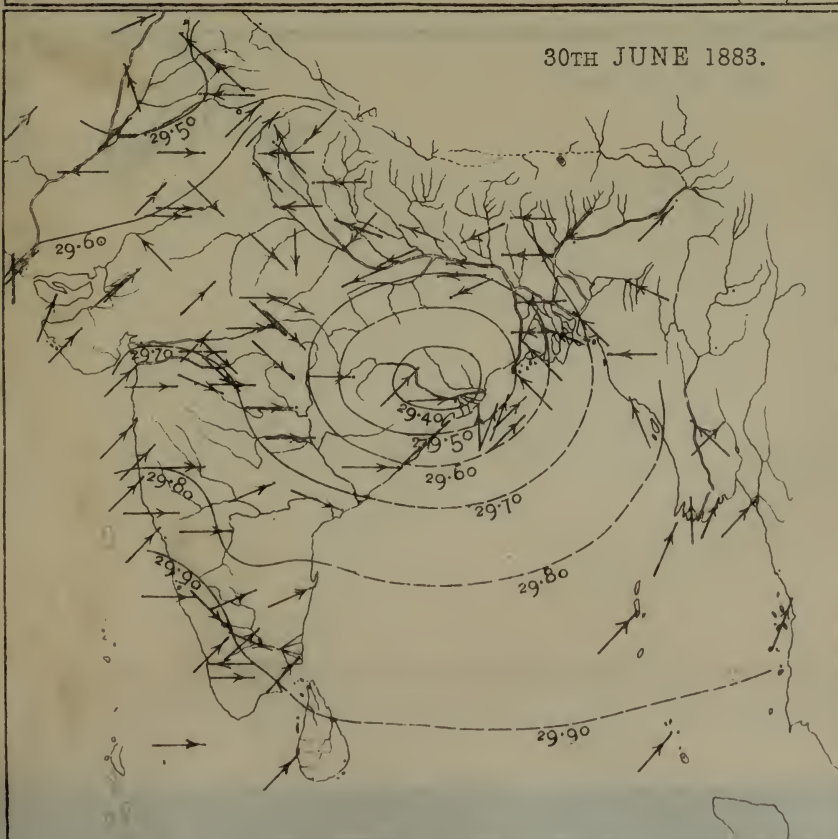
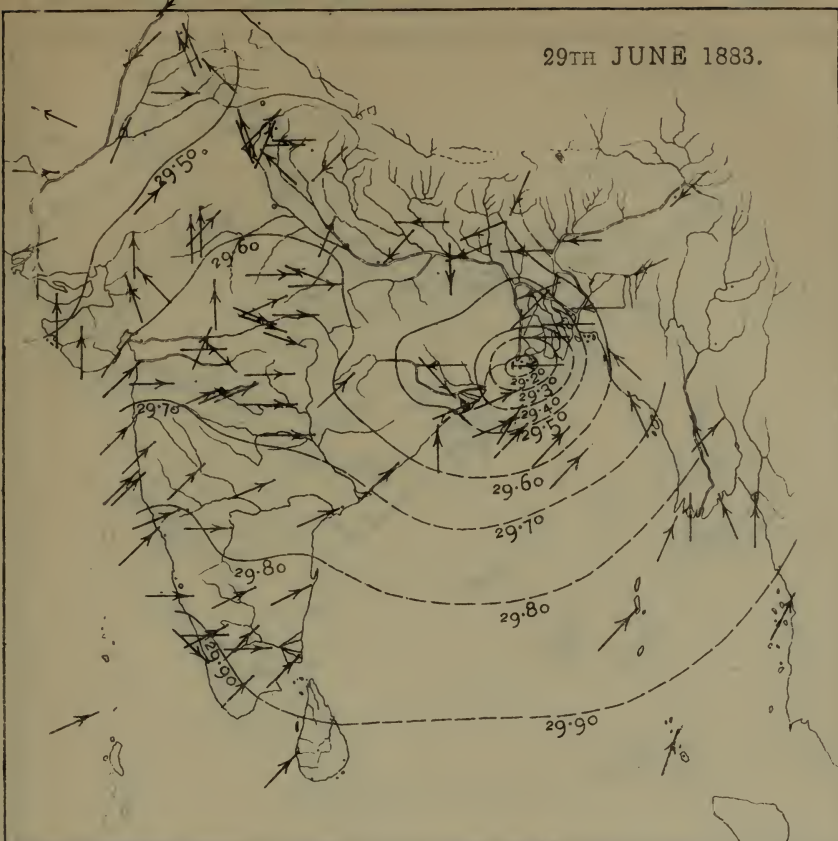
The charts give the distribution of pressure and wind directions at 10 A. M. of each day. They are based on the 10 A. M. observations taken at the land meteorological stations, and on the 8 A. M. or noon observations taken on board the ships which have furnished logs of the weather experienced by them in the Bay during either storm, allowance being made, wherever at is possible, for the difference of time between the two sets of observations.



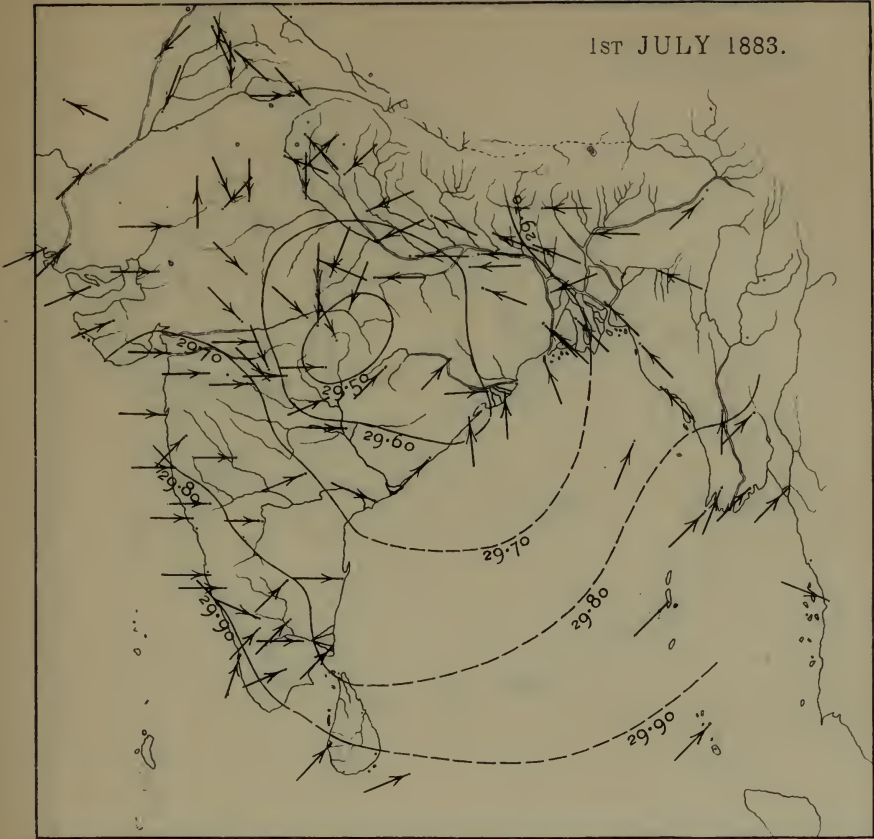




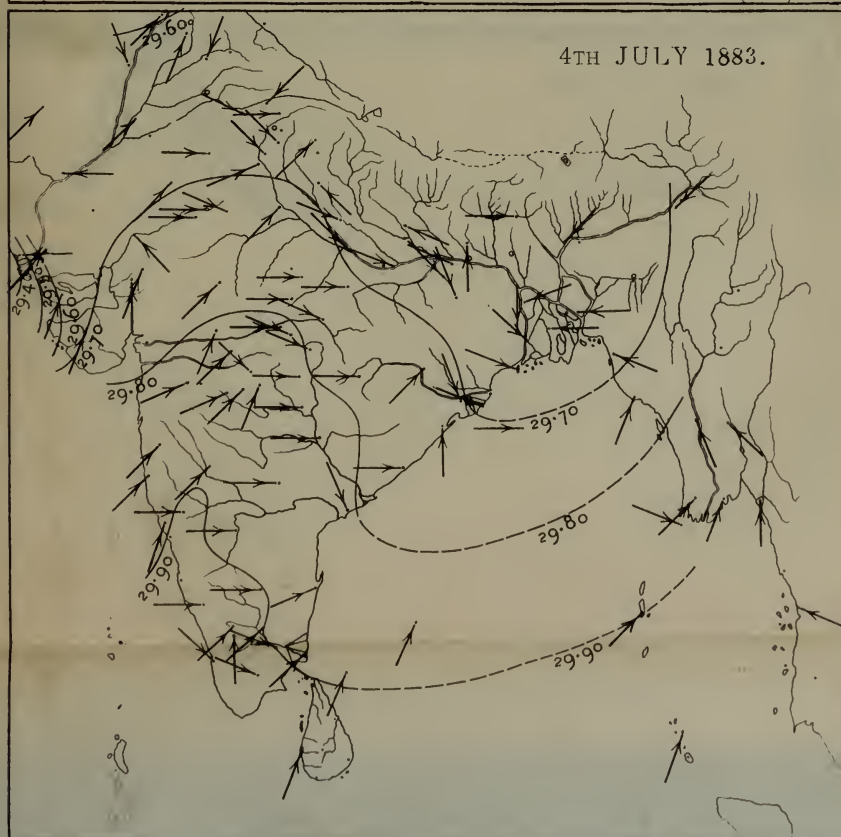
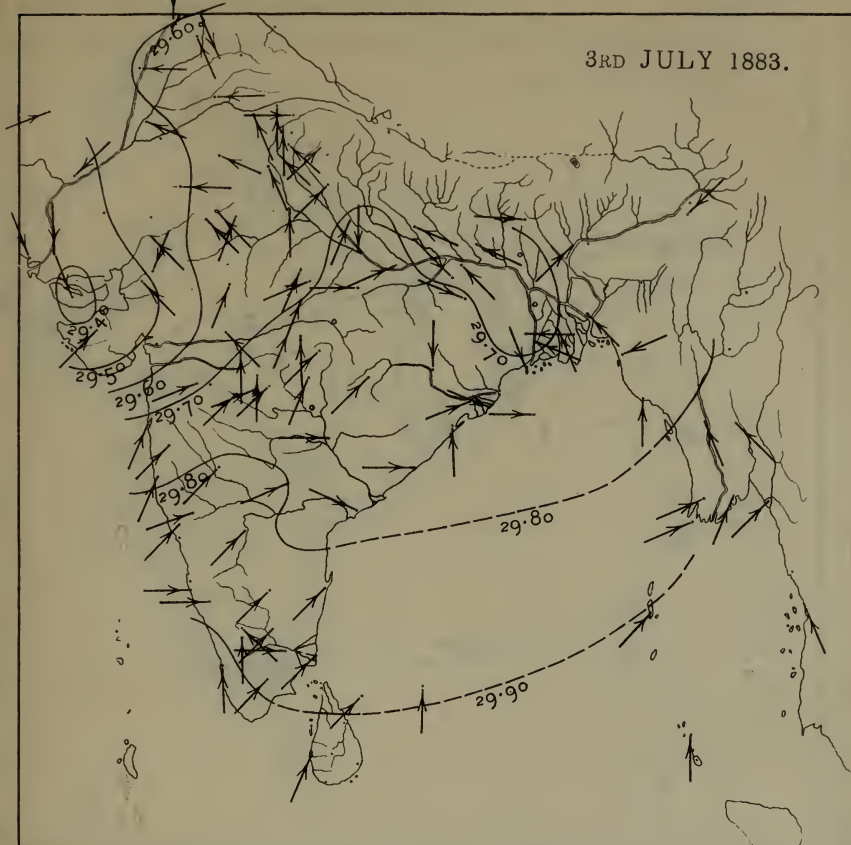


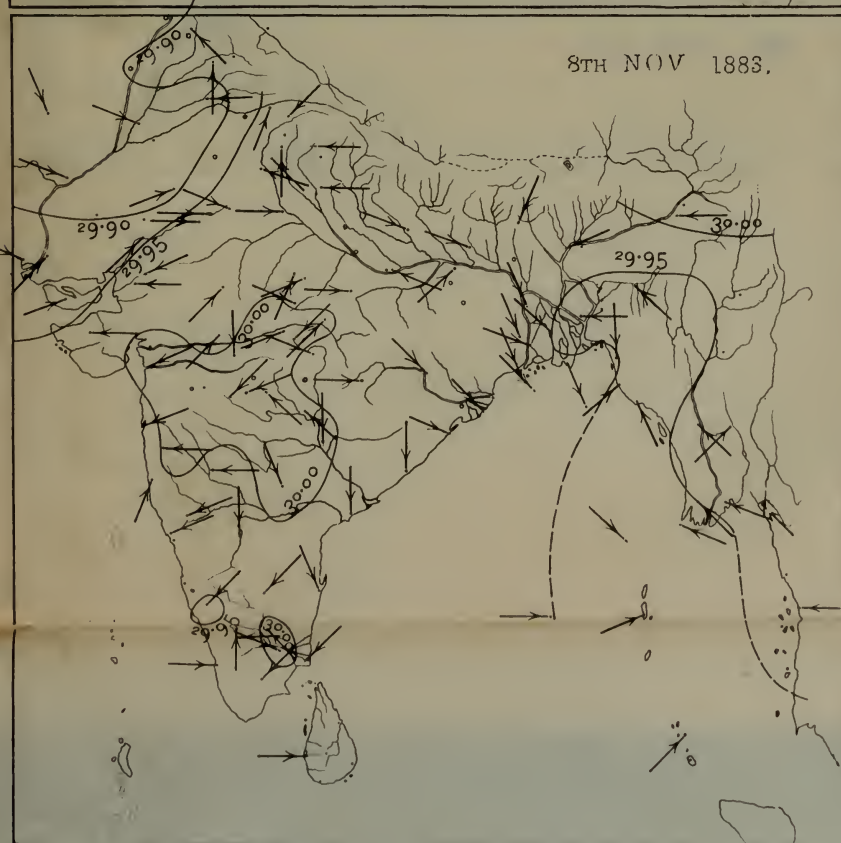
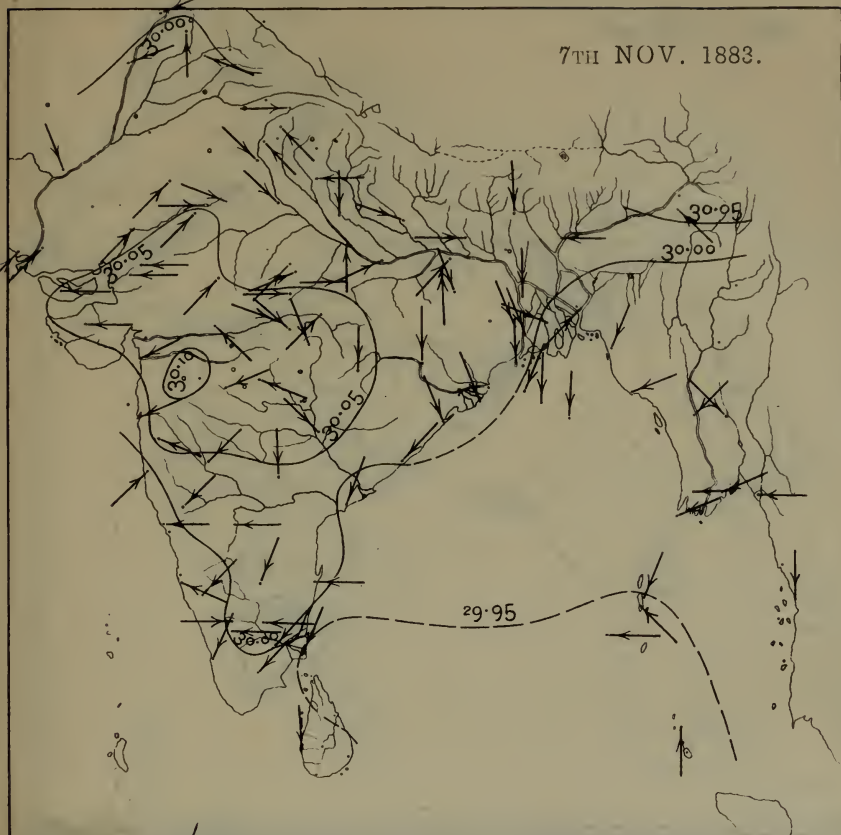




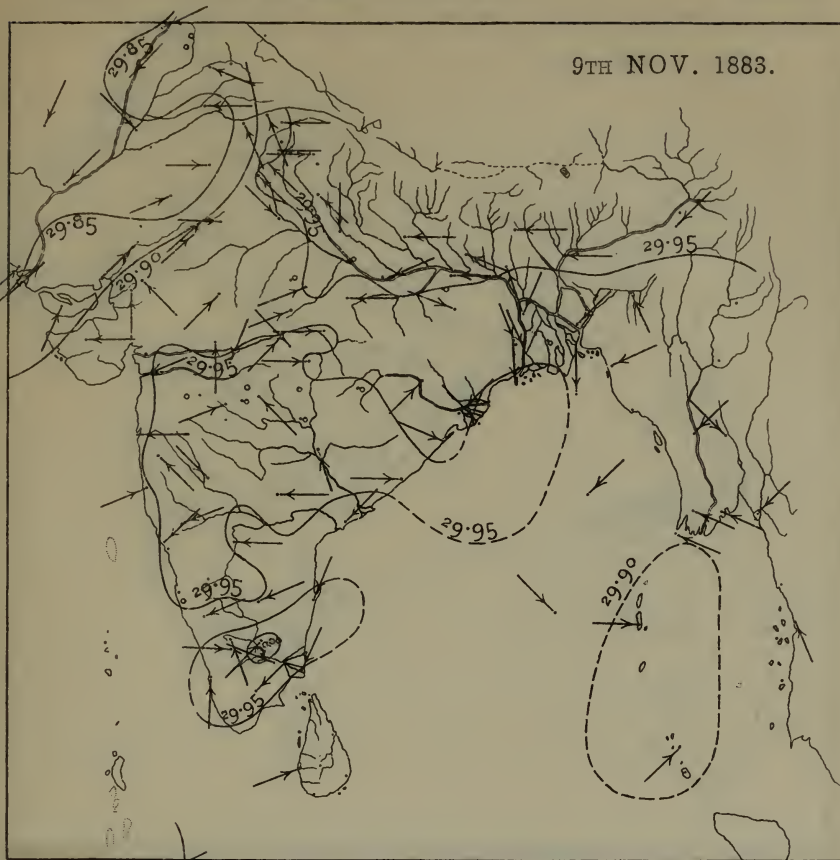








9TH NOV. 1883.



10TH NOV. 1883.

